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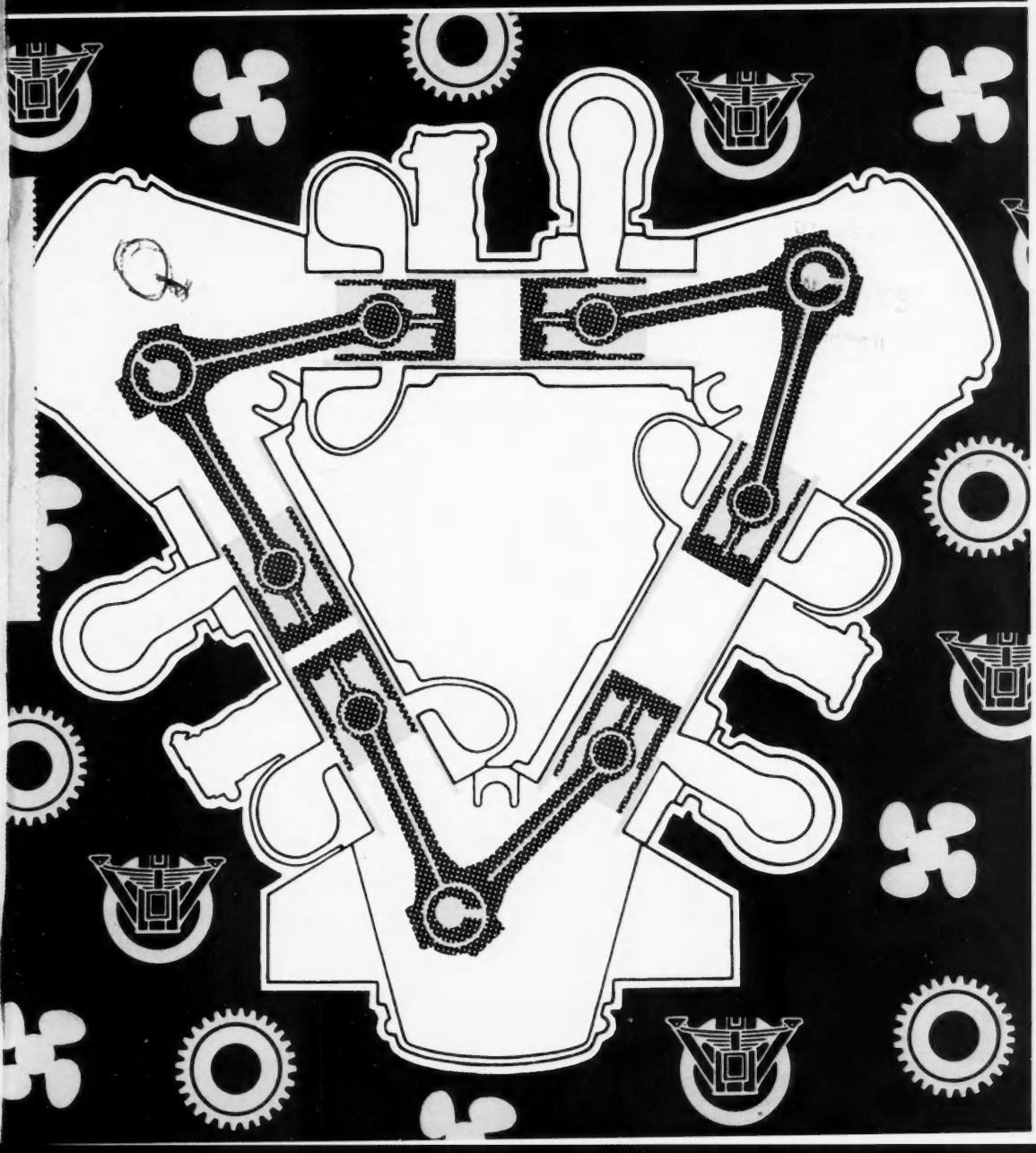

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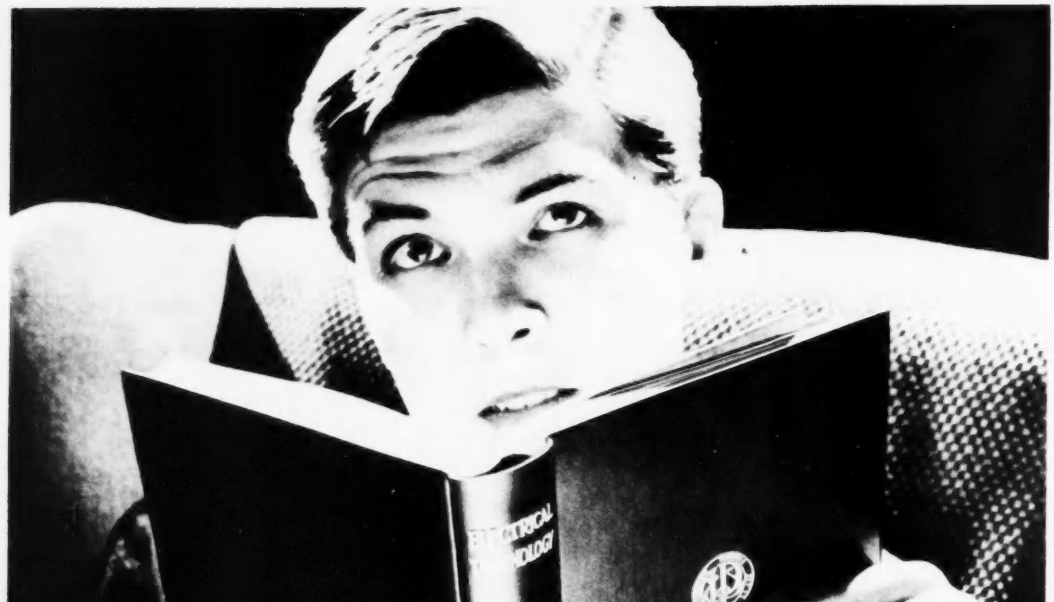
COVER PICTURE: A cross-section of the Deltic diesel engine, fully described in the article on p. 6. The artist has surrounded the section by the three symbols of the engine's main uses: for ship propulsion, railway traction, and stationary power units.



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THE PROGRESS OF SCIENCE

GALILEO'S CLASSIC EXAMPLE

Three hundred years ago Galileo, scientist, astronomer, painter, poet, and musician died. During his lifetime his experiments and discoveries stimulated the imagination of the ordinary man to an extent not experienced previously and unequalled since. Today it is instructive to recall these early achievements as they provide us with a frightening example of Man's intolerance to new thought.

Galileo's genius was apparent early. At school his observational prowess was demonstrated when, praying in the cathedral one day, his attention was distracted by the movement of a hanging lamp. He counted the swings and noticed that the time for each seemed to be the same, although the swings got shorter and shorter. Later experiments verified this phenomenon and thus the principle of the pendulum was established.

At the University of Pisa, Galileo mastered the fundamentals of Euclid and Archimedes, and at the age of twenty-six was appointed Lecturer in Mathematics. One day he climbed the steps of the Leaning Tower of Pisa. He carried two weights, one large and one small. Reaching the uppermost gallery he balanced the weights on the edge of the balustrade and then, with a brief glance at the watching crowd below, he carefully pushed them off together. Until that moment it had been assumed that bodies of the same substance fell at speeds proportional to their weight. This theory had been taught by Aristotle and had apparently been believed for 1900 years, yet no one had done a simple test to see if it were true. The simultaneous clang of Galileo's two weights proved, at last, that Aristotle had been wrong.

The demonstration was not appreciated by Galileo's audience. The University Fathers left the square convinced that "this meddlesome man Galileo must be suppressed". Their antagonism was so great that Galileo soon left Pisa and took up a professorship at Padua. Here his lectures, covering diverse subjects such as motion, fortifications, sundials, mechanics, and the nature of the Earth, soon attracted notice. But Galileo's main claim to fame was to come through his astronomical discoveries. To appreciate the significance of these we must know the conditions prevailing in the world of scientific thought some three centuries ago.

Nearly 1400 years previously Ptolemy had summarised the astronomical findings of his predecessors in a mighty book, the contents of which have come down to us in the form known as the "Almagest". In his time he was undoubtedly a great mathematician and astronomer. Naturally he made mistakes, one of his greatest being his belief that the Earth was the centre of the universe, and Man the centre of creation. The other planets were assumed to turn about the Earth, but as their observed positions came to be more accurately determined, it became more and more difficult to regard their paths as being rotational movement around the Earth. To explain their antics it became necessary to introduce a complicated system of circles and secondary circles. Ptolemy's final solution was an incredible system of "eccentric-circles" and "epicycles". As more knowledge was gained additional "epicycles" had to be introduced until the complexity of the systems would tax even the capacity of a modern electronic brain. Yet such was Ptolemy's reputation that his opinions were believed for well over a thousand years. Not only were they believed, it became dangerous not to believe them. In the century preceding Galileo, the Polish astronomer Copernicus devoted thirty-six years to developing a theory placing the Sun at its true position at the centre of the solar system. But in the main, all the world's leading scientists believed in the Earth-centre system, and in the course of time this had become so established in the minds of men that, accepted more as a religion than a science, it seemed heretical to question it.

Galileo at first accepted the long-established Ptolemaic theory, but soon turned to the Copernican theory, substituting the real motion of the Earth for the apparent motion of the heavens.

In 1604 there appeared a *super nova*—a cosmic explosion denoting the disintegration of a star—and Galileo gave a course of three lectures on it. The significance of the "new star" was that its appearance upset another Aristotelian doctrine on the immutability of the universe. According to this the heavens were unchangeable, perfect in every detail, neither growing nor decaying. Yet here was a star which, previously invisible, was momentarily shining brighter than Jupiter. The professional astronomers of the time were annoyed, first at the appearance of the star, and secondly with Galileo for drawing attention to it. Another great controversy blew up, and Galileo accepted the challenge. Openly, he repudiated the Ptolemaic conception of the solar system in favour of the Copernican theory, placing the Sun in its true position at the centre of the solar system. It was a bold step. Instead of the Earth being the centre of creation, as had been taught and believed for a thousand years, Galileo postulated the very reverse. The Earth was no more than an insignificant speck compared with the vastness of the universe; the Sun only one among millions.

Grinding the delicate lens with his own hands, Galileo succeeded in making a telescope which could magnify thirty times. He looked at the Moon, and found that in many respects it was very much like the Earth, with mountains, valleys, craters, plains, rocks and, apparently, seas. Wherever he looked, Galileo found new stars. The Milky Way, that faint band of light which appears to form an arch across the sky at night and which had for long puzzled the ancients, he found to be composed of thousands of stars.

But it was on January 7, 1610, that Galileo made his most sensational discovery. Examining Jupiter carefully he noticed that near it were three little points of light, assumed to be stars, and on the following night he saw they had moved to the planet's other side. During the next four days Galileo's suspicions were confirmed. The

points of light were not stars, but satellites; the arrangement formed a solar system in miniature.

Kepler, the famous German astronomer and Galileo's friend, accepted the new disclosure and issued a book, although it upset some of his own earlier conclusions. The great mass of professionals, however, refused to believe it. A Florentine astronomer of the time wrote:

"There are seven windows in the head, two nostrils, two eyes, two ears, and a mouth; so in the heavens there are two favourable stars, two unpropitious, two luminaries, and Mercury alone undecided and indifferent. From which and many other similar phenomena of nature, such as the seven metals, etc., which it were tedious to enumerate, we gather that the number of planets is necessarily seven. Moreover, the satellites are invisible to the naked eye, and therefore can have no influence on the earth, and therefore would be useless, and therefore do not exist."

Galileo's enemies were gathering against him. The Aristotelians he had ridiculed at Pisa waited their opportunity. Religious authorities wrote to the Pope in Rome asking that his teachings be forbidden. In 1615 Pope Paul V invited him to Rome to explain his views. He was well received and spent several days demonstrating his telescope to a number of Cardinals. But soon afterwards any teaching of the Copernican theory was condemned as heretical. Kepler's book was put on the forbidden list, and Galileo was ordered never to teach or to believe in the motion of the Earth.

In 1623 the Pope died, and was succeeded by Cardinal Barberino with whom Galileo had become particularly friendly during his earlier visit to Rome. Gaining confidence at his friend's rise to power, Galileo started on what proved to be his greatest literary work, "Dialogues on the Ptolemaic and Copernican Systems". In this he presented his argument in the form of an intelligent discussion between three people, one of whom was called "Simplicio", an Aristotelian philosopher, and who was introduced to put forward the stock absurdities of his adversaries. Although the book was not intended to undermine the Ptolemaic theories, the pro-Copernican arguments were so cogently put that the real belief of the author was apparent. The Aristotelians were furious, and spread rumours that Simplicio was none other than the Pope himself. There was no truth in this allegation, but the Pope's favour was withdrawn.

Instantly Galileo was summoned to Rome, and there began a series of visits to the Chambers of the Inquisition. With a psychology more appropriate to these days of brainwashing, the Inquisition submitted him to a "rigorous examination". At last the venerable old man, clothed as a penitent, was taken to the Convent of Minerva for judgment. There he was sentenced to sign the confession, imprisonment for life, and to recite the seven penitential psalms every week. He was forbidden to publish anything, to teach, or to receive friends.

The renunciation is a classic of recorded intolerance and bigoted folly. The mention of Galileo's recantation here must not be taken as implied criticism of the religious creed concerned. Even at the time the court ruling was by no means unanimous, three of the ten Cardinals present at the judgment refusing to sign. The fact is, it occurred, and this classic example of intolerance to new thought provides a lesson from which all of us can benefit. Although such intolerance is now universally condemned, there are few who can declare truthfully that they have never at any time been guilty of holding a similar attitude of mind. With the world about to launch its first artificial satellites a big step towards space travel will be taken. What the impact this greatest of scientific achievements will have on society cannot be foretold. But knowledge of the reactions to Galileo's discoveries, which provided us with the first rung of the ladder to the planets, will ensure at least that the tragic intolerance of his dark age is not repeated.

CALDER HALL AND AFTER

"Where do we go from here?" This question was never far from the surface during the symposium on Calder Hall held in London towards the end of November. Ostensibly more than 1000 nuclear engineers from Britain and abroad had gathered to put on permanent record all the intricate details of the design and construction of Britain's first atomic power station. In the circumstances a certain amount of self-congratulation was inevitable, and indeed from time to time the meeting throbbed with collective pride. At other times there were some pretty severe criticisms of the Calder Hall design—criticisms that were entirely proper and wholly to be expected when it is recalled how this great plant was built in a tearing hurry. But Calder Hall has now been built and there is an old engineering dictum that anything that has been finished is, almost by definition, out of date. It was not therefore surprising that the engineers were disinclined to rest on their laurels.

But where in fact do we go from here?

One of the outstanding impressions at the symposium was that the principles on which Calder Hall has been built can be exploited to far greater extent than was thought possible as recently as a year ago. Immediate improvements of the design, such as those which will be incorporated in the first British civil atomic power stations, will make it possible to generate electricity at the same cost as that from conventional power stations. Then, further ahead, are several major developments of the design which will lead to generating costs that compare favourably with the most optimistic estimates that have ever been made about the economic possibilities of nuclear energy.

It is no wonder, then, that the Atomic Energy Authority is faced with a considerable dilemma in the planning of its future strategy of research. Should the emphasis be on the development of the technologies necessary to build other types of reactors, or should it be on the exploitation to the limit of the possibilities of Calder Hall? It was significant that at the symposium Dr J. V. Dunworth, Head of the Reactor Division at Harwell, said that he could see no prospect of other kinds of reactors becoming economically competitive with the successors of Calder Hall for at least another decade. It would be reasonable to infer that Harwell

will compromise. Research towards the development of reactors which use liquids to carry away heat will go on, and comparatively large prototypes of these will be built. But for the immediate future the main effort will be directed towards the exhaustive exploitation of Calder Hall.

Initially some of the developments to this end will be comparatively straightforward. At the symposium Mr R. V. Moore, who was responsible for the broad principles of the design of Calder Hall, explained how, for example, the use of thicker steel in the construction of the reactor pressure container will lead to great economies. Thus an increase of the steel plate thickness by only half an inch—from two inches to two and a half inches—will make it practicable to build a pressure vessel whose diameter is nearly fifty feet—10 feet greater than at Calder Hall—and to put inside this a large reactor core. Even if this is in every other respect than size identical with the one at Calder Hall, the output of the reactor would be just twice as great. In fact engineers are now talking about the possible use of steel 3 inches thick, so that reactors with more than three and a half times the output of those at Calder Hall could be built without a proportionate increase of construction costs.

Beyond this development lies the possibility of running reactors of the Calder Hall type at higher temperatures. At present the temperature of the fuel elements themselves cannot be allowed to rise much above 400°C because of the softening in that region of the magnesium alloys which are used for canning the uranium bars. Other metals, such as beryllium or zirconium, will have to be used if temperatures are to be substantially increased. But these both have the disadvantage that they cannot conduct heat away from the fuel rods as rapidly as can magnesium and aluminium. For this reason it is likely that fuel rods canned in these rare metals will have to be made rather narrower than those in use at Calder Hall, which will in turn mean that the reactor may not be of the right configuration for use with natural uranium as a fuel. To make it work it will have to be fuelled with uranium enriched by the addition of uranium-235 or plutonium.

Superficially this sounds an expensive thing to do, but of course it must be remembered that quite soon civil power stations in Britain will be turning out substantial quantities of plutonium which will probably have to be used for civil purposes. In any case Mr Moore showed at the symposium that the advantages of running reactors at high temperatures outweigh the possible disadvantages of having to use enriched fuel. Not only would the gas temperature be raised so that electricity generation became more efficient, but also it would be possible to extract heat at a higher rate from each ton of fuel, and, equally, to extract a greater quantity of heat from each ton of fuel before it has to be discarded. These facts imply that the electrical generating capacity of a reactor of given size would be increased and that the cost of its fuel would be reduced—in simple terms, that the cost of electricity would be markedly reduced.

This, however, is not the end of the story. There was a great deal of talk at the symposium of making reactors run at such high temperatures that it would be economical to use the cooling gas to drive a gas turbine directly—not to make steam first and use that to drive a steam turbine. At these temperatures—800°C or more—metal fuel elements would become quite unserviceable. Compounds of uranium which are refractory at high temperatures would have to be used instead and, according to Mr Moore, uranium carbide is the most hopeful of these. It would still be necessary to use enriched uranium as a fuel, but it seems that it will be possible (if the technical difficulties are overcome) to extract heat from it between ten and twenty times faster than in the first civil power stations.

It is interesting that in this extreme development the engineers now see the possibility that gas-cooled reactors on the Calder Hall pattern (with perhaps a different cooling gas) may not have to be bulky and clumsy like their progenitor. It may even be that it will then be economical to use gas-cooled reactors for generating electricity in small quantities, and for meeting off-peak demand for it. It may even be that reactors like Calder Hall will become good competitors in the fields of ship and aircraft propulsion.

If this is so, Calder Hall will have far surpassed the hopes of the men who designed it three years ago.

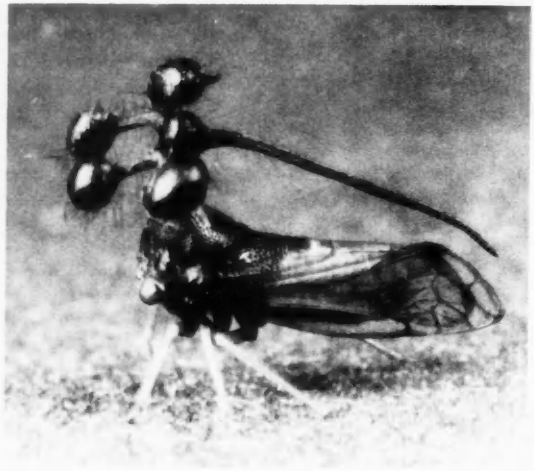
"COWS" OF THE INSECT WORLD

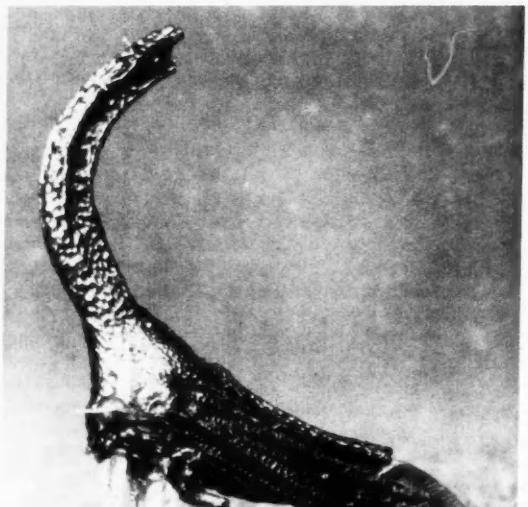
Membracides are oddly shaped insects akin to the grasshopper but rather resembling some prehistoric monster or an invention of science fiction. Like grasshoppers, they have four wings, the anterior pair being soft and membranous. Like the bumps and nodules that cover their bodies, the wings are relics, remnants of organs which appear no longer to function.

It has been suggested that these apparently superfluous "spare parts" are disguises to make the membracide resemble his own enemies, particularly ants and flies. But membracides have other enemies whom they do not resemble, and ants and flies have enemies of their own, a circumstance which would soon render void the advantages of such a disguise. The suggestion can therefore be discounted. It is more likely that the oddly shaped horns and antlers, nodules and bulbs are the result of over-development in the distant past, and that in these membracides nature overstepped herself.

There are about 2500 known species, most of which live in Africa, Australia, tropical America, and the Indies. Only four species are known in Europe, and of these only two are found in Britain, where they are called tree-hoppers, or devil-hoppers. One American type, the *Ceresa bubalus*, was first noticed in France in 1912 and is thought to have entered the country on a cargo of imported fruit. M. Claude Dupuis, the French naturalist who studied the insect, was amazed at the rapidity with which it spread over the country, particularly since it can fly only for brief and erratic spells.

Most membracides live in trees. Eggs are laid once a year, usually in a crack bored in the bark of young





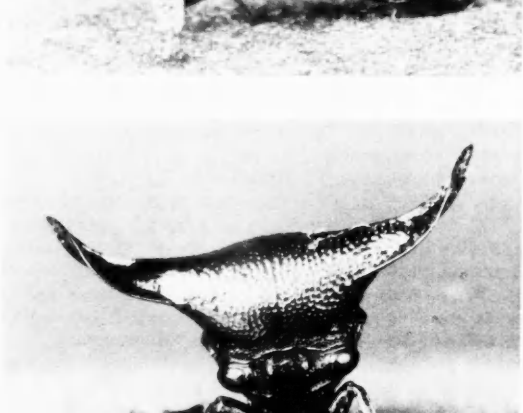


FIG. 1. (*Top left*) *Bocydium*, tree-hopper, or devil-hopper, a member of the Membracidae family of insects. FIG. 2. (*Top right*) *Spongophorus*, another membracide. FIG. 3. (*Bottom left*) *Ceresa bubalus* was originally American and was first discovered in France in 1912. FIG. 4. (*Bottom right*) *Centrotus cornutus*.

trees by the female. Three to eight eggs are laid, and they are sometimes covered with a pad of wax which protects the eggs and hides the mark. Another member of the family, *Ceropides*, is responsible for the sticky deposit known to country folk as "cuckoo spit". It is the home of the *Ceropides'* grubs. The grubs of the membracide are born to type, with feathery growths along the head and thorax.

But the most useful and most startling function of the membracide is that, like the plant-lice, it ejects a fluid like "honey-dew", much prized as food by ants. It is, in fact, the cow of the insect world, and is often reared in ant-hills in much the same way as cows are reared by man. The ants have even learned to stroke the membracide in such a way as to "milk" it, inducing it to produce a drop of the sticky fluid.

M. Jack de Cuziat, of Paris, who took the photographs of the locust gaining its wings (DISCOVERY, July 1956, p. 267), is also responsible for the photographs of membracides published with this note.

SEX DETERMINATION BEFORE BIRTH

In recent years, methods have been developed for ascertaining the sex of an individual by an examination of certain tissue cells. The first demonstration that sex determination by these means was possible came from Murray Barr, in Canada, in 1949. He was able to show that there were sex differences in the minute structure of certain cells in the brain and spinal cord of the cat. Soon afterwards it was shown that similar changes were present in certain cells in the skin and that these changes could be demonstrated in humans. Small portions of skin were removed and thin sections cut for microscopical examination. It was found that in the nuclei of the epithelial cells certain structures were commonly present in the female which were not present in the male. These structures take the form of small masses of dense nuclear material which are often found to be lying against the nuclear membrane and which are plano-convex bodies about 1 micron in diameter. The exact relationship between these bodies and the specific female chromosome is not yet determined. Not all the epithelial cells from females show these structures, and in a recent paper the percentage of such cells which do show them has been stated as varying between 30 and 50. A simpler way of carrying out this examination has recently been reported in which, instead of removing portions of skin by a surgical operation, scrapings are taken from the inside of the mouth. Such scrapings always show superficial cells, and these, although perhaps not ideal for the purpose, will serve very well for sex determination. Sex differences in male and female nuclei can also be found in some of the white cells of the blood, as was shown by Davidson and Smith in this country. Here the cells in question have lobed nuclei, some of which carry projecting masses of nuclear material. In the female these masses have a drumstick appearance, whilst in the male they are simple club-like projections.

For centuries men have tried to forecast the sex of a child before its birth and recently these methods based on minute cell structure have been applied to the problem. The developing foetus is surrounded in the uterus by a bag of fluid, and cells from the skin are shed into this fluid. Serr, Sachs, and Danon, working in Israel,* have collected specimens of this fluid either by puncture of the uterine membranes just before birth or by abdominal puncture earlier in pregnancy, and have examined the cells present in the fluid for the structures specifically associated with sex. They have been able to predict the sex of an unborn child in this way with accuracy and the method appears to be a reliable one.

It may be asked what are the practical applications of these methods of sex determination in general and of prenatal sex determination in particular? One obvious use of the general method is in the field of forensic medicine. An accurate diagnosis of sex either from portions of skin or from blood could clearly be of value in many police investigations. Again, there are a number of unfortunate individuals whose sex, because of anatomical abnormalities, may be in doubt. The external appearances may be misleading and in these cases it will obviously be of importance if the true sex can be rapidly and simply determined by the means described. As far as the prenatal determination of sex is concerned the advantages may not be so apparent as the answer will surely be manifest granted a little patience! However, there are rare conditions of abnormality of structure or function which are known to be sex-linked and in these cases foreknowledge might be of importance.

* *Brit. med. J.*, October 6, 1956, p. 795.

A NEW ACE

The work of development and construction of a new high-speed computing machine is now nearly half completed at the National Physical Laboratory. The design of this machine is based upon the experience in logical and engineering techniques gained from the experimental ACE Pilot Model (which has been in regular computing service in the Mathematics Division since 1952) and also from the more recently installed DEUCE which is an engineered version of the ACE Pilot Model.

The new machine is, too, a much more powerful computing tool than its predecessors by virtue of its increased speed, of its larger storage capacity or "memory", and of its many additional functional facilities.

The new ACE in a typical day's working will average 20,000 three-address operations per second, and its overall speed will be at least four times greater than that of the DEUCE. The mercury delay lines and magnetic drums will store a total of $1\frac{1}{2}$ million binary digits. This will allow the solution of very complex problems which have hitherto been beyond the capabilities of existing computing machines.

It was first shown at the N.P.L.'s open day on May 25, 1956. Also shown was a novel automatic graph plotter. This enables information in punched card form to be automatically plotted as a graph. The equipment will also be able to accept information from a keyboard or punched cards.

The information punched on the cards is contained in decimal form in two sets of four columns to provide the X and Y co-ordinates, and a column to select the appropriate one of ten possible symbols.

The cards are handled by a standard card reader and the information from this is fed to a relay store in the converter unit. This selects the appropriate voltage to be fed to the X-Y recorder unit, but no movement of the recording head is allowed until all the information, including the correct printing symbol, is available and has been checked. The recording head then moves to its new position, checks itself and finally plots the point on the paper.

Brief specifications of the graph plotter are: Card plotting speed: generally better than 20 plots per minute. Accuracy: better than 0·15% of full scale. Scale factor: variable with coarse and fine control. Recording method: paper sheets or rolls may be used, using vacuum holding if required. Power supply: 200–250V 50 cycles per second single-phase 5 A. Overall dimensions: 32 inches by 50 inches by 37 inches high, together with the converter unit 20 inches by 20 inches by 46 inches high.

RESEARCH IN INDUSTRY: ENGINES AND POWER PLANTS

COLIN WILLMOTT, B.A.

D. Napier and Son Limited, London

The object of this article is to examine closely what is entailed in a programme of research carried out by a commercial organisation—in this case D. Napier and Son Ltd—on the projection and development of a new and complex engineering undertaking, calling for the widest use of knowledge in the many branches of engineering science. There could be no worthier recipient of such an investigation than the modern aero-gas-turbine, or the high-powered, high-speed diesel—or both.

PRIME MOVERS

Twelve years ago the Company had developed and was producing in quantity the famous "Sabre", the most powerful piston-driven aero engine of its time. Aviation was, however, demanding still more power, and this the piston engine could not supply whilst still maintaining a reasonably low weight of machinery. Thus attention had turned to the gas-turbine. In their investigations, Napier used the simple single-spool design which has since proved successful.

But the piston engine was not abandoned. A revolutionary new design of a high-speed, opposed-piston diesel has since been successfully developed as a marine, rail traction, and industrial prime mover.

Moreover, the idea of combining a conventional diesel engine with an exhaust-driven turbine, both coupled to a propeller, resulted some years ago in an aero engine with a power/altitude performance so far ahead of its time that its specific fuel consumption remains unsurpassed today. This development is being exploited fully in future projects.

Quite often a proportion of the cost of industrial research is shared by the tax-payer. The Government, in the administration of its defence programme, has played a large part in broadening the field of research investigation through the many contracts it has placed with private firms and through its research establishments. Often there has been close co-operation, not only between these separate bodies, but also with the various research associations sponsored jointly by Government and industry. One example of this co-operation is the Company's research into the design and development, and the ultimately successful flights of ramjet and rocket engines, which has been assisted by the National Gas Turbine Establishment and the National Physical Laboratory.

Napier research is conducted in four separate establishments, each dealing with a specific type of investigation. In the large research station at Liverpool, installed with its vast machinery to provide a wide range of operating conditions and dealing with aerodynamic phenomena and gas-turbines, investigations are made into compressors, turbines, and their associated gas-passages. One section alone of the laboratory draws its power from the complete engine-room equipment of a "Hunt" class destroyer delivering 20,000 h.p. to the axial compressor-testing plant.

This supply has to be very adaptable. Two steam turbines were originally laid out to provide 10,000 h.p. to two compressor-testing plants; if the need arose they could be united to deliver 20,000 h.p. to one test plant. The power absorbed recently by a research compressor reached 8500 h.p.; future projects will absorb much more power.

For the development and calibration of gas-turbines, the test laboratory is installed with an 8000 h.p. regenerative electric dynamometer and auxiliary equipment, whilst there is a 1500 h.p. electrically driven test plant for compressor calibration, and a dynamic cascade rig for investigating stage performance and the flow processes occurring in an axial compressor. Smaller laboratories have air-flow and water-flow apparatus also used in these investigations.

RIG-TESTING

Rig-testing of equipment, whether it be a component or a whole working unit, is carried out to make investigations of a scientific nature, thus an engine's running conditions of fuel pressure and shaft speed are simulated to test the engine governor which normally requires these conditions. The rig, which itself may be highly intricate and expensive, is built to enable the equipment to be tested, and generally is designed to produce phenomena such as high stresses, speeds, and temperatures, together with means of recording these. Both compressor and turbine units, translating great power with finely built machinery, need to be very carefully designed, and it has therefore become standard practice at Napier and Son to rig-test thoroughly both compressor and turbine before assembling each prototype engine.

Whilst all this work is part of the programme of the Liverpool research station, in London the Mechanical Laboratory is concerned with specific components, rig-tests, and minute investigations which can be made into any feature of a gas-turbine component. This department is engaged on many studies of a highly secret nature and little can be written at this stage about a high proportion of its equipment. One study, however, in hand at present is not so restricted. It is on the problem or problems of vibration.

STUDY OF VIBRATION

Vibration in any component of a gas-turbine causes the engineer many a headache, since it can lead to fatigue failure. Present-day gas-turbines rotate at speeds so much higher than their predecessors that the speeds of discs below which vibrations do not occur are far

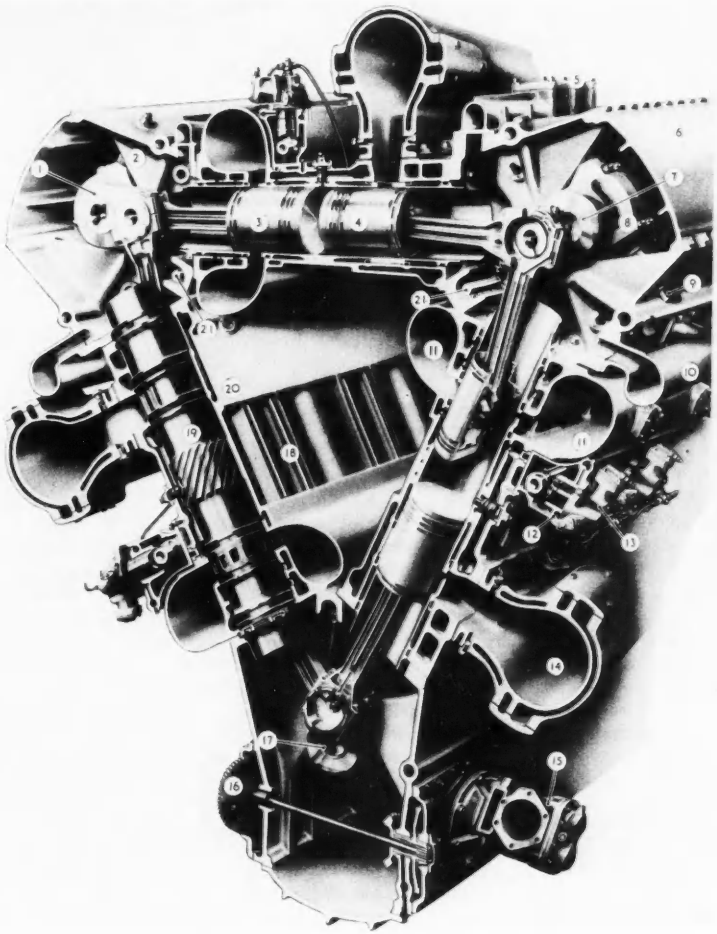
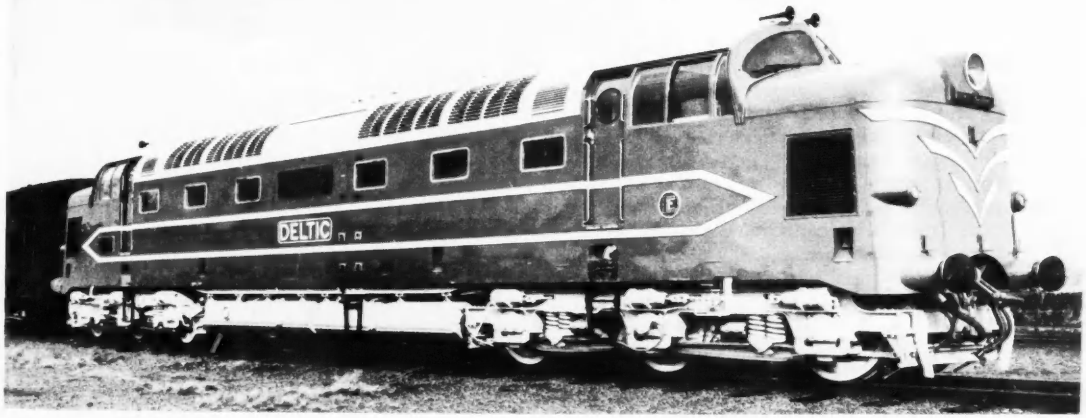


FIG. 1. (*Left*) Napier Deltic 2500 b.h.p. diesel engine; section through No. 5 cylinder viewed from driving end. (1) "BC" crankshaft; (2) "BC" Crankcase; (3) Inlet piston; (4) Exhaust piston; (5) Crankcase breather; (6) "AB" Crankcase; (7) "AB" Crankshaft; (8) Main bearing cap; (9) Crankcase tie-bolt; (10) Drain oil manifold; (11) Air inlet gallery; (12) "A" Camshaft casing; (13) Fuel injection pump; (14) Exhaust manifold; (15) Sea-water pump; (16) Fresh-water pump and pressure oil pump drive gear; (17) "CA" crankshaft; (18) Cylinder block tie-bolts; (19) Cylinder liner; (20) "C" cylinder block; (21) Blower flexible drive shafts.
(The letters "A", "B", and "C" refer to the three component parts of the Deltic engine.)

FIG. 2. (*Below*) The English-Electric locomotive built for British Railways and containing the Deltic diesel engine.



exceeded and are a possible source of trouble. Early compressor speeds of 6000 r.p.m. have gradually increased to over 20,000 r.p.m.

The frequency at which a blade will vibrate can be calculated and then verified by experiment, and it is necessary to ascertain accurately not only this frequency but also the nature of the vibration. To reveal the vibration modes in a compressor disc, a special vibrator, consisting of a coil wound round an iron core and energised by an alternating current of 60-volt amps, is held near the surface of the disc, which is clamped in a horizontal plane. Induced eddy currents react on the vibrator pole and cause a vibratory force on the disc, which is then sprinkled with sand. In this way the mode of vibration set up at a particular frequency is shown; the sand settles on the disc nodes, or on the lines along which there is no vibration.

One of the earlier methods of examining blade vibration was by mounting the blades in a holder and exciting them into resonance by bowing them with a 'cello bow. Lycopodium powder sprinkled on the blades identified the nodes excited, and the frequencies of vibration were determined electronically. Research eventually developed other electronic methods giving readings of an accuracy well above those obtained by any manual method.

One of the more difficult problems associated with blades is the measurement of stresses caused by vibratory forces under conditions of high speeds and temperature. Such measurements are normally made by strain gauges, and so it became necessary to devise methods of applying these minute gauges to the parts under investigation and of wiring them to recording machines in order to take readings during the running of the engine. Careful experiments eventually provided the right answer; it is now possible to obtain these highly important facts from the engine under test in any conditions.

How is this done? Two types of strain gauges are being used at present, one being a grid of very fine resistance wire which is cemented to the blade in such a way that when the latter bends under strain, the wires are stretched or compressed, thus altering their electrical resistance. But variations in resistance are very small, and this fact, coupled with other practical difficulties, encouraged development of a new system of measurement.

This resulted in a capacity gauge, made of copper or nickel foil, which is inserted under a blade platform and connected by a single wire to a coil mounted concentric with the turbine shaft. The rotating coil and condenser gauge form a circuit with a very high natural frequency, in the order of 20 to 30 million cycles/sec. When the blade vibrates slight changes in the capacitance of the gauge occur, altering the natural frequency of the rotating circuit. The change in frequency gives a clear indication of the stresses caused by vibration

FLIGHT-TESTING OF AERO ENGINES

Third of the four Research Divisions is the Flight Development Establishment. In 1935 the Installation Design Department was formed at Acton to deal with the increasingly complex problems arising from new engine airframe combinations. A small flight-testing section was formed at Northolt in 1938, and in 1940 this was moved to Luton Municipal Airport, becoming the nucleus around which grew the Installation Experimental Establishment, now known as the Flight Development Establishment. The main business of the Establishment has been the prototype installation and flight testing of the Company's aero engines, involving the conversion of suitable aircraft into flying test-beds.

Further technical effort has been devoted to the design, manufacture, and development of a pilotless test vehicle for a programme of ramjet research under a development contract initiated by the National Gas Turbine Establishment.

In competitive industry it is always necessary to think of future development; higher speeds of communication might, for example, be achieved by rocket power and maintained with the use of ramjets. At Napier, both systems are being developed at present.

The Propulsion Division of the Flight Development Establishment was given the task to make a specific vehicle, namely a self-contained ramjet engine fitted with four stabilising fins.

The ramjet is essentially a tube, with no moving parts, and so shaped that when travelling at a sufficiently high speed in the direction of its longitudinal axis, air is compressed due to the forward speed, then heated and expanded through the jet nozzle at its rear end.

A ramjet test vehicle made by the Company recently created a British height record. All work on the project and ancillary equipment, including ground handling trolleys and the flight launching ramp, was completed at Luton.

THE CENTRIFUGE

Ramjet test vehicles are accelerated to speed by boost rockets which separate in flight while the vehicles carry on under their own power. The high changes of speed and acceleration, together with pressure and temperature changes, cause problems of liquid and gas flow, some of which can be solved with the aid of the centrifuge which exists at Luton.

This apparatus, which is among the best of its kind in the country, is housed in a covered well, 25 feet in diameter and lined with reinforced concrete. It consists of a long arm which may be rotated at high speeds, and a model or component may be mounted on the end of the arm and be supplied with such fluids as air, water, kerosene, and nitrogen. These, and electricity, can be directed down the central shaft and along the arm to the test-piece. The apparatus is below ground level, and is designed to rotate at a maximum speed of 210 r.p.m., generating a centrifugal acceleration of approximately 100*g*.

ROCKET-PROPULSION

The Establishment is fully equipped to carry through a rocket-engine project from inception to completion. The Rocket Propulsion Section carries out all development testing of liquid propellent rocket engines. The

FIG. 3. Twin Napier "Oryx" gas producers drive this tip-jet reaction rotor for helicopters at the Flight Development Establishment at Luton. The test tower was built for "Oryx" engine development.

size of such components as pumps and valves is indicated by considerations of weight, and the very high rates of flow and pressures to be handled have resulted in wide departures from orthodox designs.

DE-ICING INVESTIGATION

The scope of research work is extended, and the flight testing of heater systems made possible, by the use of specially equipped Vickers Viking and Avro Lincoln aircraft which are maintained by the Establishment, whilst wind-tunnel testing in connexion with the work at Luton is done at the Ministry of Supply's Icing Wind Tunnel at Artington, which is staffed by Napier personnel.

THE RESEARCH DEPARTMENT

Last but certainly not the least of the research divisions is the Research Department, situated at the Main Works in Acton, supervised by the Chief Research Engineer, and equipped with both the personnel and the apparatus to deal with a wide range of problems. Piston-engine development work is also carried out by this department. There, single-cylinder test-rigs fulfil for piston engines most of the functions which the equipment in the Napier Research Station at Liverpool and the Mechanical Laboratory at Park Royal perform for gas-turbines.

The chart shows the personnel of the Research Department divided into groups and sections. These are designated by numbers and letters and not by technical titles, since to commit them to a specific type of investigation would be to sacrifice that flexibility which is essential in a versatile research organisation. The group is the larger team, composed of a number of sections. For convenience these are only shown in group A of Fig. 7. The breakdown into groups and sections will remain, although these vary in number, depending on the research programme.

Most of the problems dealt with in the Research Department are either in answer to specific inquiries and requests from the designer, or are initiated within the Department to fill a gap in its scientific knowledge. Into the former group fell much of the work connected with the early research and development on the Deltic diesel engine.

This 2-stroke high-speed diesel engine marks a new departure from standard diesel engine designs. It involves a triangular configuration in order to accommodate three crankshafts. The cylinders are disposed along the sides of an equilateral triangle, with two pistons in each cylinder.

Several designs of the Deltic system have been worked out, but the two engines being produced at present are with 9 and 18 cylinders, influenced mainly by power requirements. An 18-cylinder engine develops a maximum of 2730 b.h.p., although the triangular space in

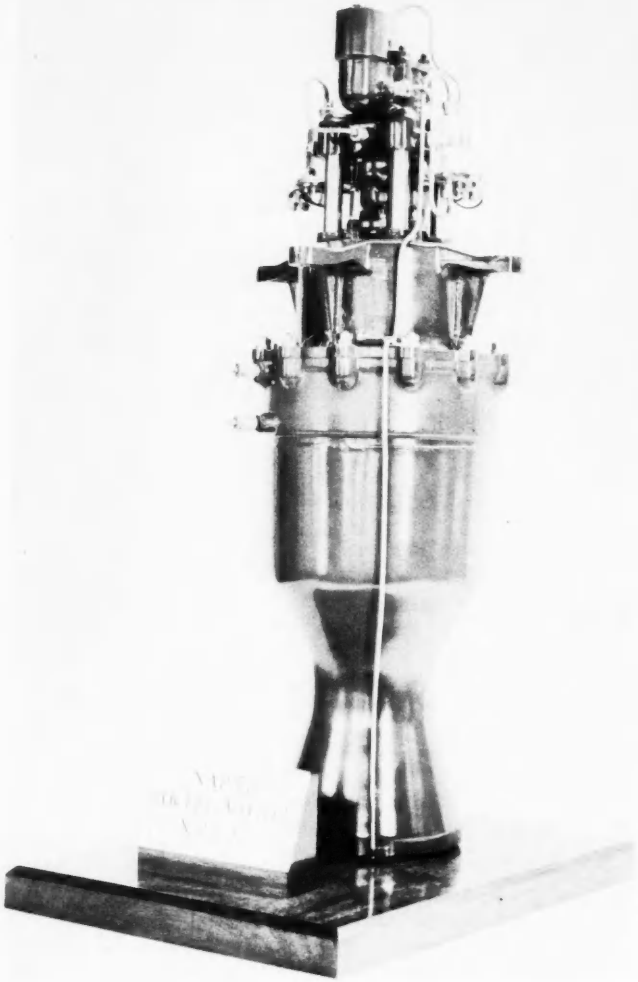


FIG. 4. (*Left*) A Napier ramjet test vehicle built for the N.G.T.E. These motors are ineffective at low speeds (up to 300 m.p.h.), since it is high forward speed which produces the air compression.

FIG. 5. (*Above*) Rocket motor N.R.E. 17 designed and produced by D. Napier and Son Ltd., Luton.

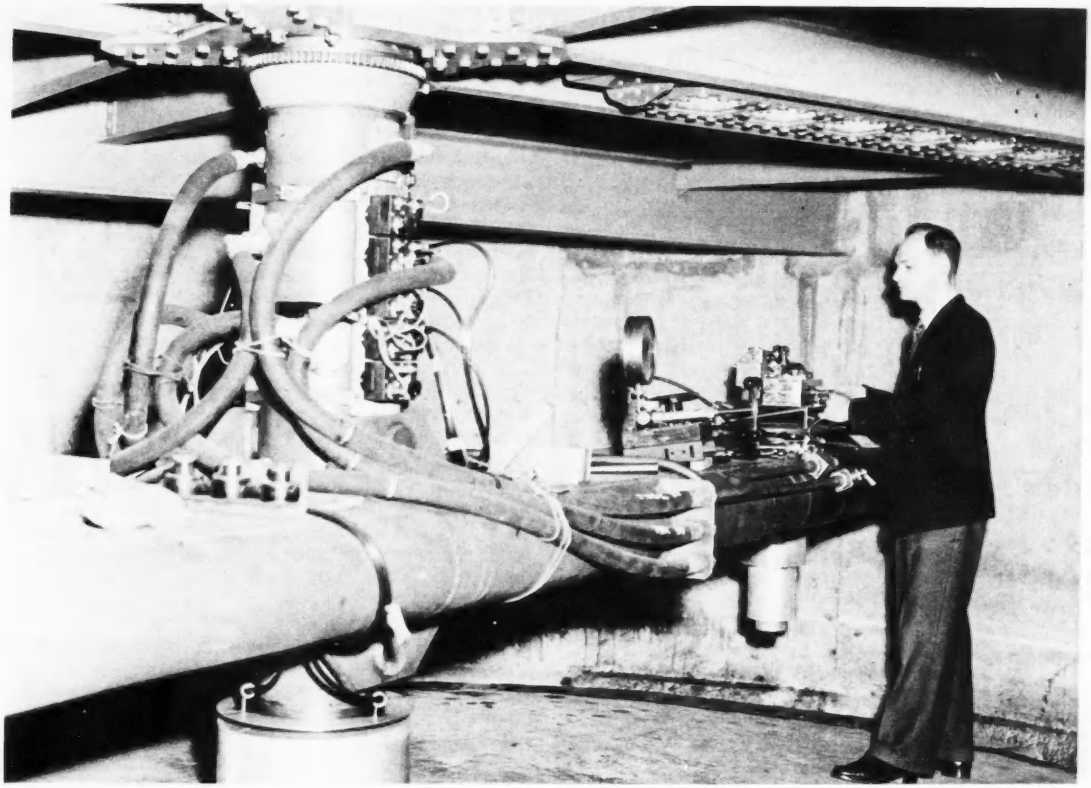


FIG. 6. Inside the centrifugal pit showing a component being mounted on the arm for testing. The arm is 19 ft. long, of welded steel construction, mounted on a vertical shaft and driven by an 85 b.h.p. V-8 engine through a multiple belt and final bevel transmission system. An auxiliary turntable 20 in. in diameter is mounted on a spindle at one end of the arm and is connected by the spur and bevel gears to the centrifuge transmission system through a clutch, which allows the turntable to be rotated under power or locked in any position. Through this device, a model or component may be mounted to point in one direction throughout its rotation.

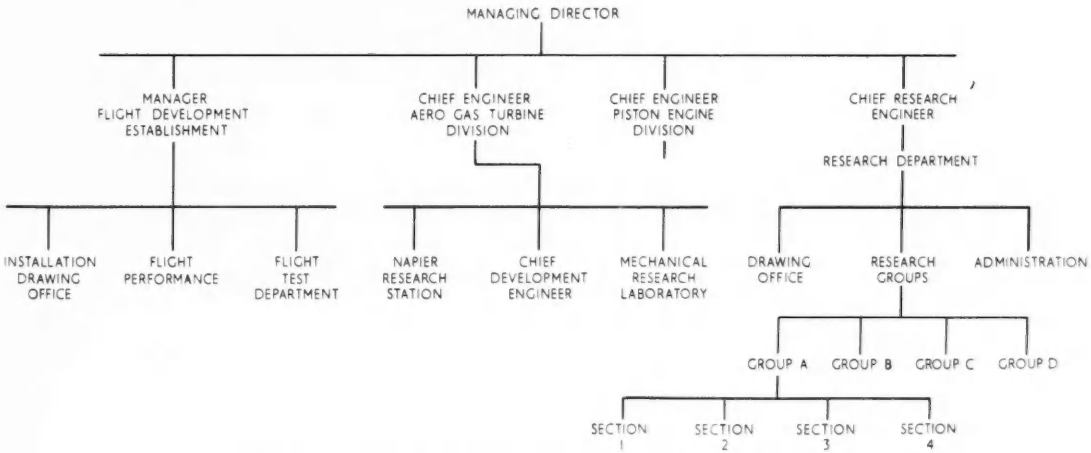


FIG. 7. A chart showing the various departments of the Napier Research organisation.

its centre, bounded by the banks of cylinders, is of the correct size to accommodate a turbo-charger, which would still further increase its power.

The engine is considered revolutionary in its own field, and posed many new problems. Only some of these could be solved by previous "know how".

Before the inception of the Deltic, experience in 2-stroke cylinder scavenging had been obtained through the construction of a single-cylinder, single-piston test rig. Although primarily concerned with another engine, the Nomad, this apparatus simulated cylinder conditions during one piston stroke, and recorded the amount of scavenging, or clearing of combustion gases, effected.

Substantial increases in power resulted and this ready knowledge was applied to the Deltic single-cylinder test rig, with its two pistons and two crankshafts; this produced ideal scavenging conditions.

It was necessary also to discover the speed of axial rotation, or "swirl" of the combustion gases within the cylinder. Several methods were considered, but all designs were restricted by the narrow gap between pistons and the operating temperatures and pressures. It had to be capable of rotation at 20,000 r.p.m. with a minimum of friction. The final apparatus chosen was a vane anemometer which incorporated a vane, rotating on a miniature ball bearing, set on two non-magnetic forks, in the base of which was set a coil.

The vane, light in weight, was introduced into the cylinder between opposing pistons at their top-dead-centre position, so that it rotated in a plane perpendicular to the cylinder axis. Each vane-tip rotation excited this coil, the electrical impulses being transferred through an electronic counter into a reading of revolutions per minute.

RESEARCH PAYS OFF

Where research carried out was of fundamental nature it sometimes contributed not necessarily to the progress of the Deltic alone, but also to future engineering programmes. The scheduled uprating of the Deltic's power, for example, causing increased load in the fuel injectors, initiated a basic study of transient pressures, and of the propagation of pressure pulses and shockwaves in hydraulic pipe lines of small bore. This investigation resulted in both the redesigning of certain mechanical components and a possible basis for the design of a new injection system.

Quite often the research engineer, in carrying out research connected with a particular problem, will tumble to the solution of other problems which he or others will find of value.

In order to investigate the high-performance characteristics of bevel gears, for example those employed in gas-turbines, a high-speed bevel-gear test rig was built. To possess bevel gears capable of taking the same loads as their spur gear counterparts greatly simplifies some engine designs. This stage has now been reached and, with aid of this rigid test rig, built to accommodate high tooth loads and relative movement between bevel gears in three different planes, these gears can be studied under misaligned conditions. This allows for minor inaccuracies in gear case castings. One can foresee that future large diesel engines may dispense with large spur gears, and save space and expense as a result.

No detail, however small, should be overlooked by the research engineer. Pistons, control systems and governors, exhaust conditions, vibrations, and fuel injection have all required individual attention. Even a large refrigerator played its part in carrying out cold-climate starting tests.

Research, therefore, is continuously shadowing the Company's products, whether they are already in service, in the course of manufacture, or exist only on the drawing board. Every situation of an engine—bench running, installation and testing, operational duty at sea and in the air, on rail, and in power house—brings its own particular problems, thereby supplying and demanding more information.

The answer to all this research is in the products themselves. In the air three quite revolutionary types of prime mover today lead the helicopter field. The Eland propeller turbine, the 3000–4200 e.h.p. single-shaft engine (incorporating a compressor with very high-stage loading and with the operating line well removed from surge), installed in a Varsity, an Elizabethan, and a Convair 340 and with nearly 1400 flying-hours to its credit, is soon to make an appearance as the power unit of the new Fairey Rotodyne and later the Westland "Westminster" 40-seater helicopters.

The Oryx, a gas-generator, exploits the principle of gas-driven rotor blades, and greatly simplifies the complicated transmission mechanisms sometimes associated with helicopters.

The Gazelle free-turbine engine introduces the principle of direct drive from engine to rotor and can be installed at any angle between the horizontal and the vertical. Already chosen for the Westland "Wessex" and Bristol 192 helicopters, it also has fixed wing applications.

The Royal Navy and a number of foreign navies operate fast patrol boats and minesweepers propelled by the most powerful diesel engine for its size in the world. An engine that by its design and performance heralds a new age at sea and on land, for today it drives the world's most powerful locomotive, on British Railways.

Of ramjets, the Company can claim the existing height record. In the rocket field, security still forbids details, but already the "Scorpion" rocket engine and the Napier Tip Thrust Unit have been demonstrated at Farnborough, and others are on the way, and soon interesting new developments will be seen. Turning lastly to turbo-blowers and Spraymat, equally important aspects of Napier production, each requiring its share of research—it is sufficient to say of the former that these are in service in sixty-nine different countries, and of the latter that to date this efficient de-icing system has more than 30 million miles flown to its credit.

Research infinitely justifies the important place given to it in industry.

INSECT HORMONES

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One fundamental point of difference between a vertebrate animal and an arthropod—say between a mouse and an insect—is that the skeleton of one is inside the animal but is on the outside in the other. Moreover, while the skeleton of the young mouse is a living tissue which can grow as the mouse increases in size, the external skeleton of the insect is a relatively inert shell which cannot grow and is capable of only a limited amount of stretching. Just as a child has to discard old shoes for newer and larger ones as its feet grow, so an insect has to change its external skeleton at intervals while the body is growing. Once a new cuticle has been formed, the general form and size of the insect are frozen until the next moult. In the same way as the simple sandals of the toddler can be changed by degrees into the elegant court shoes of the débutante by replacement at intervals of the old shoes by slightly larger and more sophisticated ones, so the form as well as the size of the insect can change stepwise at the moults. The grasshopper nymph emerging from the egg, although wingless and immature in many ways, is nevertheless sufficiently similar to the adult to be recognisable as a young grasshopper. It moults a number of times as it grows, and at each moult its form progresses a little nearer to that of the adult, although the change at the final moult is considerably greater than at earlier ones.

Insects which show this gradual acquisition of the final form are considered to represent more primitive groups than those such as flies, beetles and butterflies, which show the three distinct stages of larval, pupal and adult form. In these groups, the immature form is widely different from that of the perfect insect—contrast the maggot and the blowfly, the caterpillar and the moth—and when it moults, the same juvenile form is retained until the final stages of development. The immature and adult forms are so widely different in structure that a simple moult from one to the other is not possible, and an intermediate pupal stage occurs. A fully grown caterpillar may contract into a barrel-shaped form and moult to give a pupa (i.e. a chrysalis), and then very deep-seated changes can occur within the protection of the hard rigid walls of the pupal cuticle. Tissues of the caterpillar can be broken down, and from the building material thus released new and different organs and tissues characteristic of the adult moth can be constructed, so that a major transformation of form is possible. At the final moult, the pupal case is split and the perfect insect emerges. This type of development, with abrupt changes in form, is really different in degree rather than in kind from the gradual transformation type of development, and it has been possible to produce experimentally forms which are intermediate between larva and pupa and between pupa and adult. This has been interpreted as an induced reversion to the physiologically older type of development.

MOULTING

Research workers have used many different types of insects in their study of moulting, and as will be seen later, the same agents appear to control moulting in all insects. For instance, the conditions which cause a caterpillar to moult to a pupa, rather than to a caterpillar form again, are the same as those which lead the immature grasshopper to moult to the adult form.

Moulting is a complex process and involves the formation under the old cuticle of a new one which may be larger and different in form and structure. Secretions then dissolve away some of the inner part of the old cuticle, allowing this to split along predetermined lines of weakness so that the insect can emerge. The new cuticle is first wrinkled, soft and often pale in colour, but soon takes its final form, a process often achieved by the insect inflating itself with swallowed air or by pumping blood around, as into the vessels of crumpled wings. Next a process of hardening occurs in which the soluble protein surrounding the bundles of chitin in the cuticle is converted by a tanning process into a dark, horny and insoluble cement. The cuticle is now set into its final and inelastic form. The moulting period is a dangerous time for the insect; it is soft and helpless while struggling out of the old cuticle, and if any hitch occurs the new cuticle may harden in a distorted form incompatible with further development. A precise control of the sequence of events is essential if the dangers of this period are to be avoided. All the processes of alteration and regeneration throughout the insect must be initiated and synchronised so that they are all complete when the actual shedding of the old cuticle occurs. There must be some mechanism which determines not only when a moult is to take place, but also the degree of change which is to occur and which thus fixes the form of the insect after the moult.

ACTION OF THREE HORMONES

Many physiological processes are regulated either by nervous control or by hormonal action. The former is of special value when some localised control is required, such as the stimulation of a muscle, while hormonal control enables many processes or tissues to be stimulated simultaneously. It is achieved by a specific chemical—the hormone—which is formed in a special gland and liberated directly into the blood stream. The response produced in tissues sensitive to the hormone is often dependent on the amount of hormone present or on the balance between different hormones which may have opposing actions. Many different hormones are found in the human body, and some regulate growth. Their influence may become conspicuous in the rare cases when something goes wrong with the amount of hormone released. For instance, over-activity of the pituitary gland may give too much growth hormone and lead in time to a human giant, while under-activity may

result in a dwarf. Hormones can lead to changes in bodily form, as occurs at adolescence.

When the role of hormones as regulators of growth and form in vertebrates had been appreciated, it was natural that entomologists should begin to ask themselves whether hormones might not be of equal importance in the moulting and metamorphosis of insects. Physiologists had found that the tadpole-to-frog transformation could be speeded up by a hormone and prevented altogether by surgical removal of a part of the tadpole brain. The similarity between this vertebrate metamorphosis and that of insects stimulated Kopeč, in the nineteen twenties, to try and find out if the insect brain was also essential for metamorphosis, and whether any evidence for hormonal action could be obtained. He discovered that if caterpillars of the moth *Lymantris dispar* were deprived of their brains ten days or more after the last larval moult, pupation took place and brainless but otherwise normal moths emerged in due course. If the brains, however, were removed before the tenth day, pupation never occurred although the caterpillars survived for a considerable period. Kopeč also found that if he divided the caterpillar's body into two portions by a ligature, that is, by tying a thread tightly around it, both portions would pupate simultaneously if the ligature was tied after the tenth day, but only the front portion pupated if the tying was earlier. He concluded from his results that the brain liberated a hormone into the blood which was essential for pupation, and that the "critical period" at which this liberation occurred was around the tenth day after the last moult of the caterpillar. Once the hormone had been liberated, the pupation process was initiated and the brain was no longer essential; the failure to pupate shown by the rear portions of caterpillars tied before the critical period was due to the inability of the essential hormone to pass the ligature. Kopeč also demonstrated that ability to pupate was not affected by cutting the main nerve cord, suggesting that the brain was not exercising its control through the nervous system. Similar results were obtained by other workers with different insects, and some additional lines of evidence were obtained which supported the hypothesis. The importance of the brain was confirmed by transplantation experiments in which caterpillars whose brains had been removed before the critical period (and hence were unable to pupate by themselves) could be made to pupate by implanting into their abdomens either their own brains or ones from other caterpillars. A direct proof of the existence of a hormone in the blood was obtained by Fraenkel who worked with maggots of the common bluebottle, *Calliphora*. These soft white maggots change at the appropriate time into hard mahogany-coloured puparia, a transformation which is easy to observe. Fraenkel found that if the maggots were ligatured, the results were similar to those which had previously been obtained with caterpillars. The rear portions of maggots tied before the critical period (which was sixteen hours before the normal time of pupation in this species) failed to pupate, but these could be made to do so by injection of blood taken from maggots which had passed the critical period. It was clear that the blood of this post-critical period contained some specific chemical —the hormone—which was necessary for pupation.

The simple theory that one hormone from the brain controlled moulting was soon shown to be an oversimplification. Wigglesworth demonstrated the presence of a second hormone, which he termed the "juvenile hormone". When this was present together with the moulting hormone, a moult was initiated which led to the retention of the immature form (for example, a caterpillar moulted to a caterpillar again), but if this juvenile hormone was lacking, the moulting hormone acting alone caused a moult which led to the development of adult characteristics, or a caterpillar to pupate. These conclusions followed from an elegant series of experiments which Wigglesworth carried out using *Rhodnius prolixus*, a South American blood-sucking bug which is about 2 centimetres long when fully grown. This insect has five nymphal stages, or instars, before moulting for the fifth and last time to give the adult form. In each nymphal stage, only a single large meal of blood is required, and moulting then occurs at a definite time afterwards. Wigglesworth found that the distension of the abdomen of the large meal was a necessary stimulus to the brain before this was activated to produce the hormone which sets the moulting process in motion. A series of small meals was ineffective. There was a period after feeding during which the brain was essential for a subsequent moult, but decapitation after this critical period did not prevent moulting. In some experiments, pairs of decapitated nymphs of *Rhodnius* were joined together so that there was a cross circulation of their bloods. One partner was decapitated before the critical period, and hence was unable to moult unaided; the other partner, having been decapitated after the critical period, contained hormone in its blood and so could act as a hormone donor. When two fourth instar nymphs were used, it was found that both moulted simultaneously to give fifth instar ones, and similarly two fifth instar ones joined together gave adults, showing that the donor was supplying sufficient hormone for the needs of both.

When nymphs of different stages were used, the results were very interesting. A fourth instar accepting blood from a fifth as donor did not moult to give the expected fifth instar form, but prematurely assumed the adult form. Even a first instar nymph could be made to moult in this way to give a "precocious" adult, even though it was little more than a millimetre long. These results were due to the absence of the juvenile hormone in the blood of the fifth instar donor. When the pair was reversed, a fourth instar acting as a donor to a fifth instar, the latter did not moult to the normal adult but instead gave a giant nymph. Here the juvenile hormone, normally lacking when a fifth instar moults, had caused nymphal characters to develop again and metamorphosis to the adult was suppressed. The source of the juvenile hormone was an organ called the *corpus allatum*, and results similar to those in the blood transfusion experiments could be obtained by removing or transplanting this organ. For instance, if corpora allata from fourth

or younger instars were implanted into the abdomens of fifth instar nymphs, the change to the adult form was suppressed and giant sixth instar nymphs were obtained which would sometimes moult to give seventh stage ones. The corpora allata of fifth stage *Rhodnius* nymphs were ineffective, showing that they had ceased to secrete the juvenile hormone. Removal of the corpus allatum led to premature development of the adult form. This has been demonstrated in a striking manner by Fukuda in Japan, using caterpillars of a silkmoth. If the caterpillars were deprived of their corpora allata, then irrespective of their age or size, pupation took place at the next moult. Diminutive pupae were formed from which small but fertile moths emerged: in the extreme case, the pupa formed weighed only one-fortieth of the normal weight.

The theory that two hormones were required, a moulting hormone from the brain and a juvenile hormone from the corpus allatum, soon required modification in its turn, in the light of some experiments by Fukuda. He found that if ligatures were tied round silkmoth caterpillars which had been decapitated after the critical period, only the front portion of the caterpillar pupated when the ligature was tied around the prothoracic segment. From this result, he was able to show that the actual source of the moulting hormone was not the brain but an organ in the prothorax. Wigglesworth was subsequently able to find the analogous organ in *Rhodnius*, and equivalent structures have been detected in most insects.

Hanstrom, working in Sweden, demonstated the presence of a group of large cells in the brain of *Rhodnius*, which Wigglesworth found would serve as a source of the brain hormone if the part of the brain containing these cells was transplanted. Staining of sections of insect brains with a suitable dye has given direct visual evidence of a secretion from these neurosecretory cells.

Thus we arrive at the present view which is generally accepted today, that three hormones are involved. The neurosecretory cells of the brain produce a hormone which stimulates the prothoracic gland to produce the moulting hormone; this will lead to pupation or the development of adult characteristics at the subsequent moult unless a third hormone, from the corpus allatum, is also present, when juvenile characters are retained after the moult. This scheme has been confirmed in many different species of insects, and moreover, it appears that the same hormones are utilised in different insects; for instance, a fully grown caterpillar of the bee moth can be prevented from pupating by implanting the corpus allatum from stick insects or meal worms.

ISOLATION OF THE HORMONES

Once the existence of these interesting hormones had been established, the next step appeared to be to try and isolate them in the pure state, in order to see what sort of chemical structure they possess and to facilitate biological experiments on their mode of action. Biochemists know that if such an isolation is to be attempted with any reasonable hope of success, two pre-requisites have to be satisfied. The first is that some simple specific test for the active material must be available, and this must clearly be a biological test, since the physiological activity is the only property by means of which the unknown material can be recognised at this stage. The second pre-requisite is an adequate supply of starting material. When sex hormones were isolated from vertebrate tissues, the yields obtained were minute, sometimes of the order of one part from 10 million parts of starting material, so it was therefore necessary to think in terms of hundredweights of raw material.

The problem of the isolation of an insect hormone offered a challenge which was accepted by Adolf Butenandt, one of Germany's outstanding biochemists. In 1939 he had been awarded the Nobel prize for Chemistry for his work on the isolation and structure of the vertebrate sex hormones. Later he turned his attention to insect hormones because, as he said, he wanted to try and open new doors. A satisfactory assay method was first developed from the technique used by Fraenkel with maggots of *Calliphora*. Ligatures were tied around fully grown maggots about a day before the anticipated time for pupation, and all those whose front ends only had pupated twenty-four hours later were selected, the remaining maggots being rejected. The front portion of these half pupated maggots was snipped off, and different doses of the material for assay injected into the unpupated isolated abdomens, using about twenty at each dose level. That dose which caused 50–70% of abdomens to pupate within thirty hours was said to contain one *Calliphora* Unit of activity of hormone. Over two thousand sets of assays have been done, and it is reported that the method gives reliable and reproduceable results.

Becker and Plagge had found before the war that an active extract could be obtained from the same bluebottle maggots, and had made some experiments into the physical properties of the hormone in the crude extract, such as the stability towards acids, alkalis and heat. The problem of obtaining really large supplies of these maggots appeared formidable, but Butenandt and his associates found that the pupae of the silkmoth would also give an active extract and this was very fortunate since the silkmoth is one of the very few insects which is reared on the commercial scale. In 1953, Butenandt and Karlson were able to obtain a million cocoons of the silkmoth. The silk casing of each was cut open individually; then the pupa was removed and sorted out according to sex. The female ones were kept, and the moths allowed to emerge so that their scent glands could be cut off. Butenandt was then able to attempt isolation of the scent used by the female to attract the male. The male pupae were stored in methyl alcohol until about half a ton had been accumulated. They were then crushed and the liquid squeezed out under a pressure of three hundred atmospheres, an operation which gave about 140 gallons of extract. This was concentrated by evaporation and the residue subjected to a series of extractions with different solvents, the activity being assayed frequently in order to work out the best procedure and to observe the

concentration of activity. After a long and complex series of operations involving the production of numerous fractions by chromatography on an aluminium oxide column, the hormone was at last obtained in the pure form as fine needle-like crystals. The yield was 25 milligrams, or one twenty-millionth part of the original material. The activity was extremely high, as less than one hundred-thousandth of a milligram contained one *Calliphora* unit of activity, sufficient to cause an isolated abdomen to pupate. The name *α-ecdysone* was given to it because of its role in promoting ecdysis, or moulting. Tests showed that the active material was the hormone from the prothoracic gland and was effective in all insects tested. In addition, it was found to cause moulting in the common shrimp, which suggested that the moulting hormones of crustaceans and insects are interchangeable if not identical.

CHEMICAL STRUCTURE OF HORMONE

Not very much is known yet about the chemical structure of the hormone. It was found to contain carbon, hydrogen, and oxygen only; elementary analysis indicated a formula of $C_{18}H_{30}O_4$. A study of the infra-red and ultra-violet absorption spectra suggested that it might be a hydroaromatic alcohol containing an αβ-unsaturated ketone grouping. Nothing more has been published, and further progress will not be easy as the structure is complicated and only a very small amount of material is available for biological and chemical investigation. A minute amount of a second active material has recently been isolated which appears to have the same formula but only about half the activity, and this has been termed *β-ecdysone*.

A FOURTH HORMONE?

The isolation of the moulting hormone was the culmination of eleven years' work. The isolation of the other two hormones involved in moulting will undoubtedly offer problems equally formidable. Since the corpus allatum becomes inactive in the last caterpillar stage, the pupa does not contain any juvenile hormone, but the corpus allatum is known to begin secreting again in the adult and then plays a new role in aiding the maturing of the sex organs. So it is possible that younger silkworms or adult moths may provide a material for the attempted isolation of the juvenile hormone and perhaps of the hormone of the neurosecretory cells of the brain. Fukuda has worked recently with two races of silkmoths, one of which lays eggs which hatch in a short time, and the other lays eggs which go into diapause, that is, they do not develop and hatch for several months. This behaviour of the two races can be reversed by suitable surgical techniques involving the removal or transplantation of tissues, and the results can be explained if it is assumed that a certain part of the nervous system secretes a hormone which passes into the eggs and causes diapause. Absence of this hormone would lead to non-diapause eggs. If this explanation proves correct, it will add a fourth hormone to the list.

DIVING IN THE SUEZ CANAL

CAPTAIN W. O. SHELFORD, R.N. (Retired), F.R.S.A.

The problem of clearing the Suez Canal and the need for resumption of vital oil supplies to this country is obvious to everyone. The clearing operation is absolutely dependent upon the successful employment of divers.

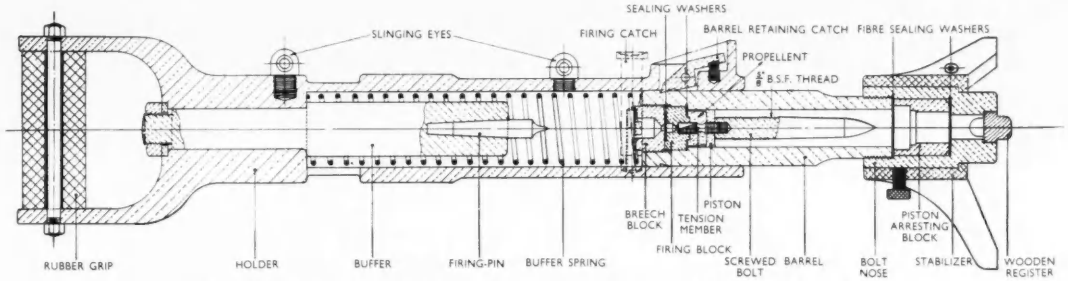
To the average layman, divers conjure up visions of men encumbered in large helmets, thick suits, and leaded boots, tied by an airpipe to a pump in a small boat. To the least nautically minded of us it must seem an impossible task for men such as these to comb out the whole length and breadth of a great waterway like the Suez Canal. Fortunately science has come to the aid of the diver in recent years, as it has to the whole field of underwater work and salvage. There are now many varieties of diving-suits and many modern tools which the diver can use.

Obviously the first thing that has to be done in an operation of this kind is to get the divers underwater to examine the obstructions; to report on the nature of them and the way they have been sunk, and to give a complete picture to the salvage officers of the problem which lies beneath them. In this case, no one can tell beforehand exactly how the Canal has been blocked. While blockships may protrude above the water and their presence is therefore obvious, a malicious enemy can strew not only the blockships, but the waters around them with delayed-action mines and booby-traps. The first search, therefore, has to cover the whole area as rapidly and minutely as possible.

Teams of frogmen are nowadays available for this early search; the suits which they wear, close-fitting and streamlined so as not to retard their progress through the water, are the result of intensive development by the rubber and plastics trades. The specialised technique of spreading light, but watertight, layers of pure or synthetic rubber on to cotton, nylon, or terylene reinforcement has produced the ideal material for underwater swim-suits.

For the frogman's breathing apparatus, neither compressed air nor pure oxygen are entirely suitable. Compressed air is a wasteful method of diving, and the breathing of pure oxygen may have a number of physiological disadvantages. The modern frogman uses a synthetic mixture of oxygen and nitrogen calculated to minimise the physiological hazards of breathing either gas in its undiluted state. The practical application of these calculations so that mixtures can be used in self-contained breathing apparatus is a development completely exclusive to the Royal Navy.

Since, if explosive booby-traps have been laid, they



Cox No. 2 Submarine bolt-driving gun. Complete assembly ready for firing the bolt.
(By courtesy of the Temple Cox Development Co. Ltd., Bromley.)

may be operated magnetically, the frogmen cannot carry compressed gases in steel cylinders. Modern metallurgy has made available cylinders of non-magnetic aluminium alloy, which not only can be charged to double the pressure normally used in steel cylinders, but which are virtually proof against salt-water corrosion.

Once the frogmen have completed their search, the salvage divers will move into action. They will still be wearing the standard diving gear supplied with air from the surface, but their early reports to the salvage officers will not have to be relayed through the unhappy medium of earphones clamped to an attendant's head. Inside the diver's helmet, small transceivers pick up the sound of the diver's voice and transmit it through amplifiers to loudspeakers on the surface, so that everyone concerned in the operation can hear the diver's report first-hand. It is possible that underwater television might be brought into use to amplify the diver's report by relaying actual pictures of the underwater scene to the surface. It is improbable that the heavy type of deep-sea television used so successfully on the search for the lost submarine *Affray* and on the astonishing salvage of the crashed Comet off Elba, will be found very useful in the shallow and confined waters of the Canal. Smaller television sets employing Vidicon tubes which can be manœuvred by the divers, acting on telephonic instructions from the surface, might well play a useful part.

Assuming that the main obstructions are blockships loaded with concrete and scrap metal, it may well be impossible to refloat them as a whole. In this case they will, of course, have to be removed piecemeal. The easiest way to remove a ship in pieces is to blow it up, but obviously the use of high explosives will be extremely limited for fear of damaging the Canal itself. A great deal of cutting by controlled explosives can, however, be done. Plastic explosives which can be moulded round girders or into the angles of plates can make a clean and effective cut without expending more than a pound or two of explosive. Small charges of polar blasting gelignite can be fixed so as to give a shearing force to a girder or stanchion and thus cut it neatly in half. Solid blocks of concrete can be neatly cracked by the insertion of comparatively small shaped charges into suitable bore-holes.

For more extensive cutting, even to the extent of cutting a whole ship in half from deck to keel, flame-cutting using a combination of oxygen and hydrogen through a special torch can be successfully employed. Experienced divers can cut through plate almost as quickly as surface operators can cut with the standard oxy-acetylene torch. An even more up-to-date development of underwater cutting is the oxy-arc technique. In this method the metal plate is heated by means of an electric arc from an ordinary welding generator, but a special hollow electrode is employed, down the centre of which pure oxygen is injected on to the plate, causing it to burn away so that a cut is obtained.

There remains the possibility of patching the damaged hulls of ships in order that they may be de-watered and brought to the surface. It is not generally known that electric arc welding can be carried out under water in the same way as is done on the surface. However, this requires a great deal of skill on the part of the diver and it is generally slower than surface welding. It is not very probable that such a method would be used in an emergency operation such as that being carried out on the Canal. A quicker way of patching is the bolting on of plates packed with rubber washers. This can be done by a tool known as the Cox's submarine gun. This gun actually shoots hardened steel bolts into the plate to be repaired. The heat generated by the passage of the first half of the bolt through the plate causes the surrounding steel to expand momentarily and then, as it is rapidly cooled by the surrounding water, the steel contracts and grips the bolt half-way along its length. The contraction, combined with the jagged edge of the hole, exerts a force on the bolt which will withstand a tensile load of 18 tons. The outer end of the bolt left protruding is threaded to take an ordinary nut. The gun is also capable of punching a clean hole in the patch to fit over the bolt. This method saves the tedious business of marking off, drilling, and tapping holes, and the screwing in of bolts which was previously necessary. This remarkable gun is also capable of firing hollow bolts into tank tops on to which airpipes can be screwed, so that compressed air can be used for blowing water out of the tanks.

Generally speaking, while the whole operation, as always, is dependent upon the skill, experience, and stamina of the men in the diving-suits, science has given them much equipment which allows the maximum effort to be applied to the job in hand, and not to the mere act of existing underwater.

IRRADIATION FOR PLANT IMPROVEMENT

P. T. THOMAS, Ph.D.

Department of Agricultural Botany, Institute of Rural Science, Aberystwyth

Our cultivated plants have developed from wild ancestors, in the first place, through continued selection by man over a considerable period of time, and secondly as a result of conscious breeding for characters which are of economic importance. The successful development of improved plants has depended not only on the presence of desirable forms in the wild, but also on the sporadic production of favourable "sports" or mutations.

Thus the wild cabbage of our sea-side cliffs (Fig. 1) has given rise, through a series of mutations, which have occurred at very rare intervals, to the many forms of the species with which we are now familiar (e.g. Brussels sprouts, cauliflower, savoys, etc.).

Likewise the fleshy cultivated carrot of the present day has developed from its stringy-rooted wild ancestor (Fig. 2).

The modern forms of sweet pea and chrysanthemum provide even more spectacular examples of the part played by mutations in the improvement of our cultivated plants.

NATURAL MUTATION

Mutations are associated with sudden changes in the hereditary materials (i.e. genes and chromosomes) which govern the whole behaviour and appearance of plants and animals. In nature, these mutations occur sporadically and at very infrequent intervals—perhaps once in every million individuals. They may be conveniently classified under the following three categories:

(1) *Deleterious and undesirable mutations.* Almost every new mutation has a deleterious or at best a neutral effect on the plant in which it occurs. It is estimated that the proportion of undesirable mutation of this kind may be as high as 99·5%. The effect may, on the one hand, be so drastic as to be lethal, and on the other so slight as almost to escape detection with present techniques. Among the more prominent effects of these deleterious mutations, which are usually recessive, are chlorophyll deficiency and sterility as well as all manner of undesirable changes in the morphology and physiology of plants.

(2) *Mutations which are favourable for species survival in the wild.* The evolution of plants in the wild has depended on the gradual accumulation through natural selection of mutations which are favourable for species survival. Of primary importance are those which confer an advantage for growth and propagation under conditions of severe competition and of unfavourable soil and climate.

(3) *Mutations which are economically valuable in cultivated plants.* With cultivated plants the breeder is less concerned with survival under relatively adverse conditions than with obtaining maximum yield and satisfactory quality under more or less favourable cultural conditions. For this reason a different spectrum of mutations from those in the preceding category will be required. Some mutations like those for resistance to disease are, however, just as important under conditions of cultivation as they are in nature.

These considerations serve to emphasise that not only are we confronted with an initially low frequency of naturally occurring mutations, but also with the fact

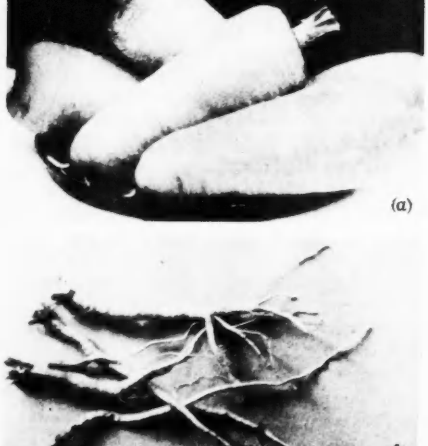


FIG. 1. (*Left*) Wild cabbage plants growing among the rocks on the South Pembrokeshire coast. FIG. 2. (*Right*) (*a*) the carrot of today; (*b*) its stringy-rooted wild ancestor.

that only an exasperatingly small proportion of those mutations are useful to the plant breeder. Thus, for the purposes of plant improvement, little could be done apart from utilising the natural variation already existing in a crop and taking advantage of any favourable mutation that might arise. Unfortunately, in our more intensively bred crops, such as wheat, we have reached a stage where the natural variation appears to be quite insufficient for the further needs of the plant breeder.

MUTATION BY X-RAY

Attempts had been made for years to increase the mutation rate of genes by subjecting plants and animals to all manner of treatments, notably sublethal poisons, supersonic vibrations, centrifugal force, electric shocks, and abnormal temperatures, but without any real success. In 1927, however, Dr H. J. Muller found that x-rays had a remarkable influence on mutation rate in the fruit fly *Drosophila*. He demonstrated that at least a 100-fold increase over the normal could be obtained in the mutation rate, and later he showed that the frequency was proportional to the irradiation dose over the range 2000 to 8000 roëntgen units. The importance of this pioneer work was fully recognised in 1948 when Muller was awarded the Nobel prize.

Muller's original discovery was almost immediately confirmed by Stadler, who had been working independently on induced mutations in barley, and it was soon found that gamma radiation from radium was equally effective in increasing the mutation rate in plants.

These discoveries led to progress in two directions; the one, a better understanding of the nature of genes, and the other, work on the more practical aspect of creating new variations for the plant breeder. It was not long before all the forms of radiation associated with atomic research became available, and their relative value as agents in the production of favourable genetic changes could be assessed.

Already it has been shown, particularly from the results of Swedish workers, that different genes vary in their sensitivity to the different forms of irradiation. But from the immediately practical point of view it can be stated that radiation with a high density of ionisation, such as fast neutrons, produces a higher total yield of mutations. On the other hand the action of neutrons is more direct on the cell nucleus and often so drastic on the chromosomes that breakage and consequent loss of genic material ensues (Fig. 3). The beneficial mutations which have already been produced have almost exclusively been the result of treatment by x-rays or gamma rays from radioactive isotopes.

Gamma radiation is readily available at reasonably low cost from the radioactive isotope cobalt 60 which has a half life of about five years. Fig. 4 shows a cobalt unit with a strength of 1800 curies which has been installed in a ten-acre field at Brookhaven National Laboratory, Long Island, New York. Various crops of economic importance are planted in concentric circles around the source so that the relative effects at different distances can be measured. The unit operates by remote control

FIG. 3. Chromosomes of beans during cell division after irradiation, showing four broken fragments which will mean loss of genes in later generations.

and elaborate precautions are taken by Dr Singleton and his colleagues to avoid accidental irradiation of human beings.

A small, but very satisfactory, cobalt 60 unit for the treatment of individual plants has been installed at the Department of Agricultural Botany, Aberystwyth.

TECHNIQUES OF IRRADIATION

Mutations can be produced at various stages in the development of a plant, but they seem to occur with greatest frequency just before or during germ cell formation. From the practical point of view and for large-scale work, however, it is most convenient to treat the seeds. The optimum dose, particularly for x-ray treatment, depends on their moisture content, and for satisfactory results it is usual to pre-soak the seeds in water.

It should be realised that since most of the mutations produced are recessive the effects on the plants will not appear until the following and perhaps later generations. Consequently, the irradiation must in general be regarded more as providing new material for further breeding than for the direct production of a new and improved variety.

In plants such as fruit trees, where a breeding programme extends over a period of many years, it is of value to try and obtain mutations which are of immediate value. For this reason attempts have been made

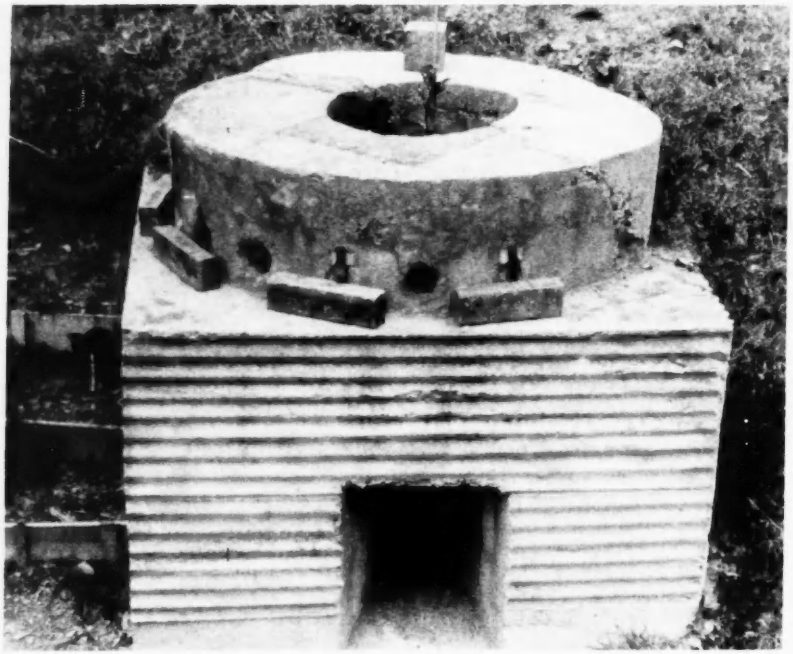


FIG. 4. The cobalt unit at the Brookhaven National Laboratory, Long Island. The crops are arranged in concentric circles round the unit which gives off the rays.

to treat vegetative buds and then to propagate them by grafting. Apart from the use of x-ray and gamma radiation it is possible to inject a nutritive solution containing radioactive phosphorus (P_{32}) into the conductive tissue of the plant. In this way the active agent accumulates in the cells of the bud growing points where it is most needed.

Already much has been achieved in the form of new and improved varieties of crop plants by the use of irradiation. Swedish workers can claim to have improved many crops which are of great economic importance, notably cereals, peas, and mustard. Not only is the yield satisfactory, but what is often of more value there is an improvement in quality involving such characters as stiffness of straw, earliness, protein content and baking quality. Another notable achievement, which was made in Germany, is the production of a fodder lupin which does not contain the usual poisonous alkaloid.

Much progress has also been made in the United States, particularly in the production of cereals which are more resistant to disease. Increased yield and variability for future breeding has also been achieved in the ground nut.

In this country the practical value of irradiation has been demonstrated in a rather different way by Dr Lewis at the John Innes Horticultural Institution in Hertfordshire. Working with cherry varieties which will not set fruit with their own pollen, he was able to destroy the self-sterility gene which is responsible for failure to produce fruit. In this way new self-fertile varieties are being produced.

SOME FUTURE DEVELOPMENTS

It is already realised that for future plant breeding it is not sufficient to rely entirely on the inherent variation which can be obtained from our cultivated plants even by irradiation. The breeder must go one step further and try to recover some of the desirable characters which, although present in the wild species, have been lost during the course of domestication and breeding. These characters include disease resistance as well as capacity to grow under relatively poor conditions. They are characters which would not have been primarily selected for in a normal breeding programme. Unfortunately, it is often found that the cultivated forms will no longer hybridise with their wild ancestors. The cultivated barleys, for example, will not cross with the wild species; and likewise wild forms of beans (which are very resistant to disease) will not combine with the cultivated field beans. But here again the use of ionising radiation may become extremely important as a means of overcoming the difficulty. Already encouraging results have been obtained in the Department of Agricultural Botany at Aberystwyth, where gamma radiation of pollen grains has been effective in breaking down some of the barriers to crossing, particularly between species of grasses.

From this brief review it is clear that there is a promising future in the use of irradiation for plant improvement. With the development of better control of both number and type of mutation that can be produced, there is no doubt that we shall have a most valuable adjunct to the established methods of plant breeding.

BEAUTY IN SCIENTIFIC INSTRUMENTS

I. THE SCIENCE MUSEUM, LONDON

R. McV. WESTON, M.A., F.R.P.S.

Although scientific instruments are only special tools for particular purposes, makers and designers have always tried to make them beautiful as well as useful. This is particularly true of many early scientific instruments, but it is also true today, if perhaps in a more restrained way.

Beauty is almost entirely a matter of line and proportions, and it is beauty of this type that can be seen today in many modern instruments. They have simple and clean lines enhanced by fine workmanship and attractive finishes. In the past, the early makers went one stage further and often added some degree of ornamentation. For example, early Babylonian weights were often made in the form of small animals. In the Middle Ages many early instruments, such as astrolabes, were of great beauty with elaborate ornamentation. They were the products of artists skilled in the working of precious metals.

Three particularly beautiful scientific instruments are here illustrated. The earliest (Fig. 1, *right*) is a nocturnal (an instrument for finding latitude and sometimes the time by night) by an unknown French maker in the late 17th century. The design and workmanship are superb. The finish and present condition are also exceptional when it is borne in mind that the instrument is constructed of iron. Notice the background of graceful foliage, very deeply cut, the intertwined ribbon pattern round the edge, and particularly the charming Signs of the Zodiac round the dial.

The instrument to the left of Fig. 1 is about a century later in date. It is a universal ring dial (an elaborate form of portable sundial for use at any latitude and

FIG. 1. (*Left*) Universal ring dial made by George Adams (*c.* 1704–73). (*Right*) A nocturnal made in the 17th century.

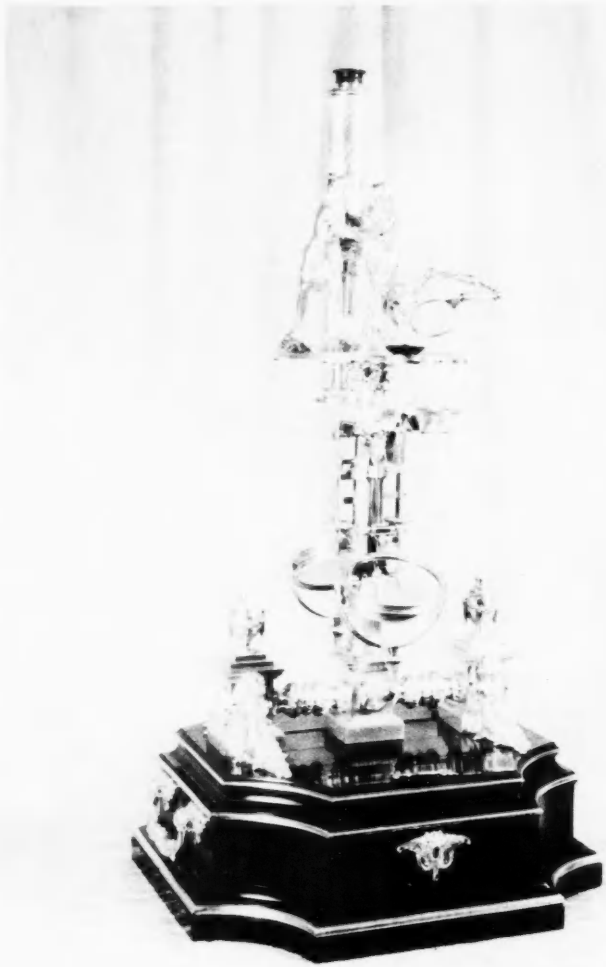


FIG. 2. Silver microscope made by George Adams in 1761 for Prince George Augustus Frederick, later Prince Regent. (*Figs. 1 and 2 were taken by R. McV. Weston, and reproduced by kind permission of the Director of the Science Museum, London.*)

with adjustments for increasing its accuracy) made by George Adams (*c.* 1704–73), and is engraved at the top: "Made by George Adams at Tycho Brahe's Head in Fleet Street, London." Though plain in design, it is supported on fine scroll brackets and is beautiful in its simplicity. The general workmanship and finish are characteristic of this famous maker of philosophical instruments. The engraving and silvering are particularly fine, and there is some restrained decoration.

The instrument in Fig. 2 has been chosen to depict the ultimate in decorative embellishment. It is a universal microscope (that is to say, both a simple and a compound microscope) in silver, again made by George Adams, in the year 1761, for Prince George Augustus Frederick, later Prince Regent, and was formerly in Windsor Castle. It is a truly noble and magnificent object, even if somewhat too ornate by our standards. It is more like an elaborate centrepiece for the table than a microscope, and, as it stands no less than 2 feet 4 inches overall, one cannot imagine that it was a comfortable or convenient instrument to use, as it must be used vertically. It is a masterpiece of design and craftsmanship typical of the age of elegance. The centre pillar supporting the instrument is in the form of a fluted Corinthian column. Crouching figures support the two pedestals, which are themselves surmounted by garlanded urns. A pair of male and female figures in the "Classical" style support the tube of the microscope. The whole is mounted on an ebony plinth fitted with two drawers to contain slides and optical accessories. The carrying-handles are massive and richly ornamented, and even the silver key is a miniature work of art.

The courtesy of the Director of the Science Museum is gratefully acknowledged for allowing the photographs to be taken.

II. THE MUSEUM OF THE HISTORY OF SCIENCE, FLORENCE

MARIA LUISA BONELLI

Curator of the Museum

As we stand on the slope of Costa St Giorgio we see on the right, half-way up and below the city gate, an old street where there is a fresco of Galileo's head and a ladder, the coat-of-arms of that great scientist.

This house on Costa St Giorgio was one of Galileo's first homes in Florence. The Grand Duke Ferdinand de Medici visited him there, as we are informed by the tablet placed above the entrance. On up the hill of Arcetri, climbing as far as Pian dei Giullari, we come to "Il Gioiello" (the Jewel), the house where Galileo spent the last years of his life. Here he was surrounded by his closest disciples, warm advocates of his doctrine and of those many ideas initiated but not to be completed by the great Tuscan. A glorious past lives again among the green hills looking down towards the River Arno. Here, between Ponte Vecchio and Ponte alle Grazie, behind the Uffizi Gallery in the Piazza dei Giudici, is the Florentine Museum of the History of Science. In it are preserved scientific instruments associated not only with Galileo and his collaborators, but also with a whole tradition, with the early steps on the road to modern discoveries and inventions.

The present President of the museum, Prof. Andrea Corsini, has been responsible for gathering together the ancestors of practically every machine or familiar instrument in our daily lives: the automatic calculator, the pedometer, the theodilite, barometers and thermometers, and also a small glass tortoise, the clinical thermometer of the 17th century.

The museum has a long tradition. Most of the instruments gathered there today adorned the Medici apartments from the time of the Grand Duke Cosimo I, and the two Medici Grand Dukes Ferdinand and Leopold attached great importance to them as a scientific legacy. It was, however, the Grand Duke Pietry Leopoldo of Lorena who gave instructions for the Museum of Physics and Natural Science to be put into order. This was eventually opened in 1775, with the Abbé Felice Fontana as Director. The museum flourished until the 19th century. Later one section of it, the

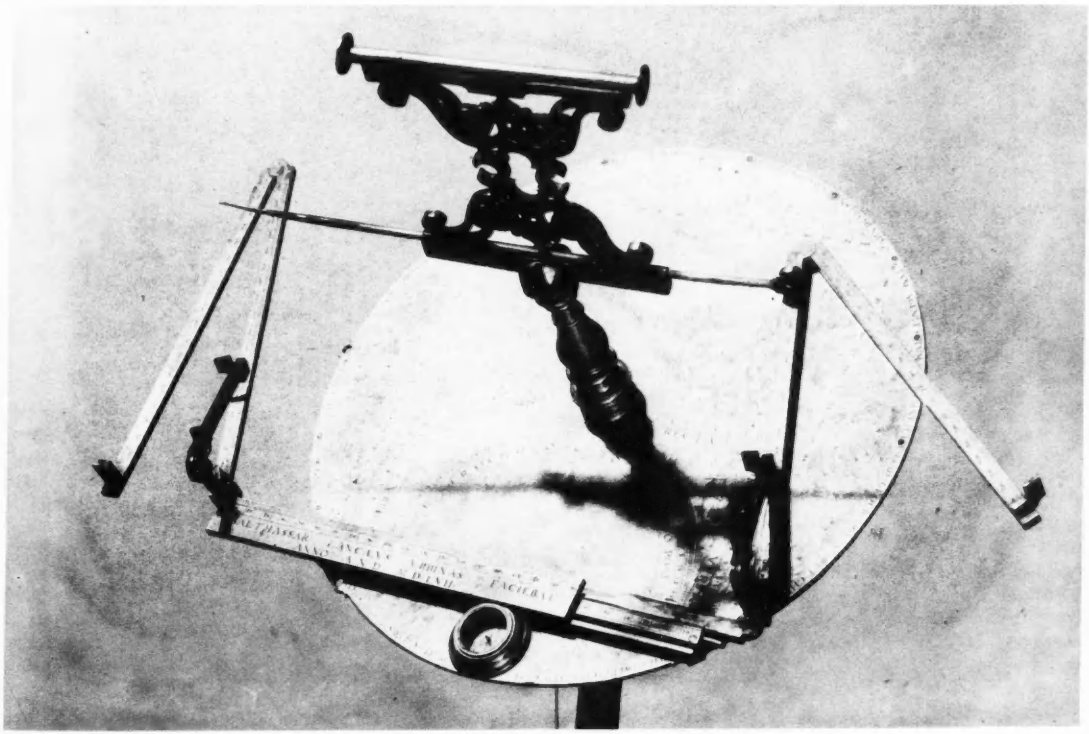


FIG. 3. Surveying device comprising a self-registering theodolite, a circumferentor and a trigonometer, made by Balthasar Lanci of Urbino, 1557. It is 30 cm. in diameter, gilt and decorated with engraved scenes showing the instrument in use. *Florence, Museum of the History of Science, item 152.*

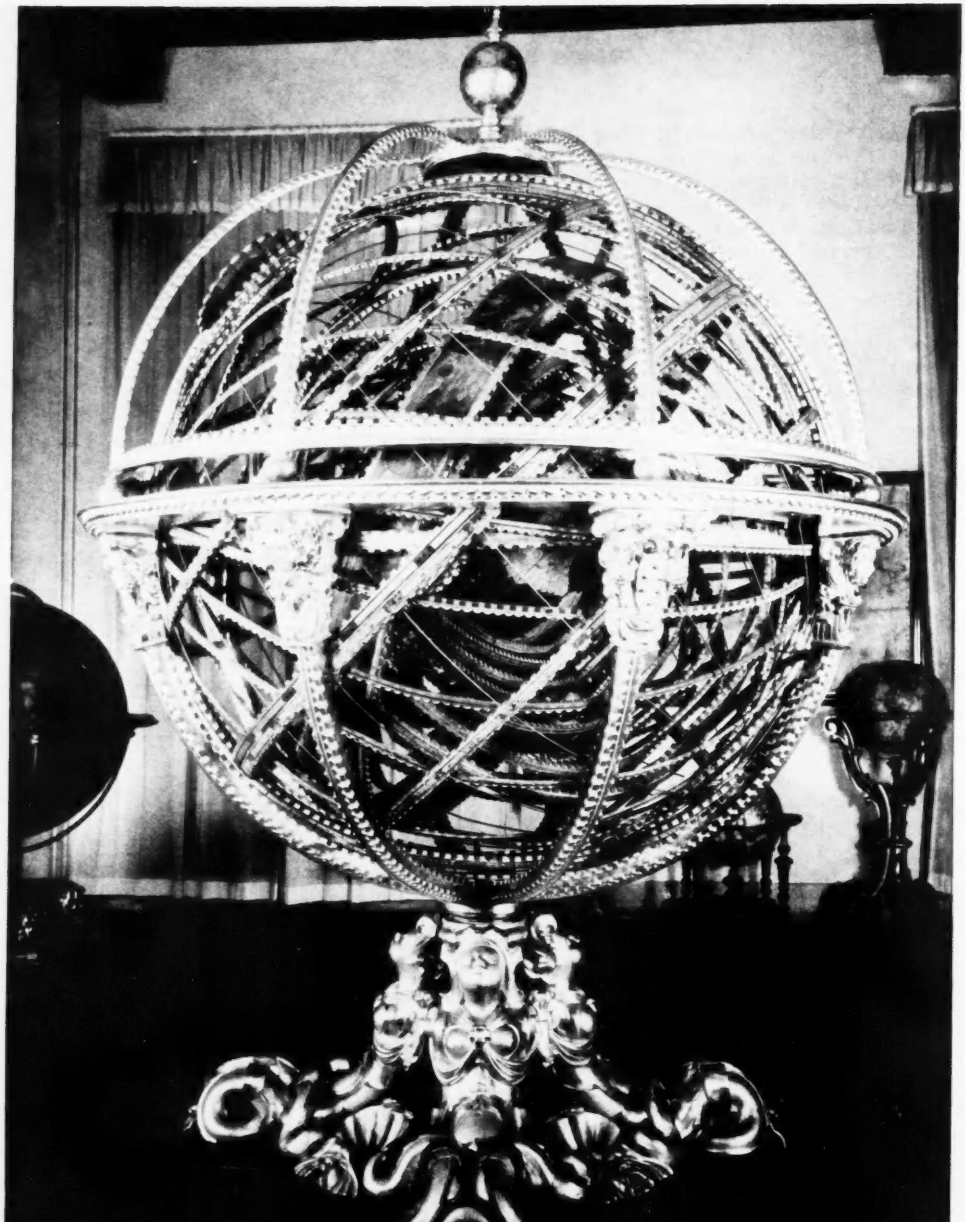


FIG. 4. Great Ptolemaic armillary sphere, made by Antonio Santucci of Pomerania for Ferdinand I. Construction began March 4, 1588 and finished May 6, 1593. It stands about 8 feet high and is almost entirely constructed of heavily gilt and carved wood. The rings represent all the celestial circles of astronomical theory (equator, ecliptic, meridians, tropics, etc.) and the paths of the Sun, Moon and planets; at the centre is a painted terrestrial globe. It is probably the most magnificent armillary sphere ever made and stands almost as a funeral monument to the Ptolemaic theory then being replaced by that of Copernicus. *Florence, Museum of the History of Science, item 714.*

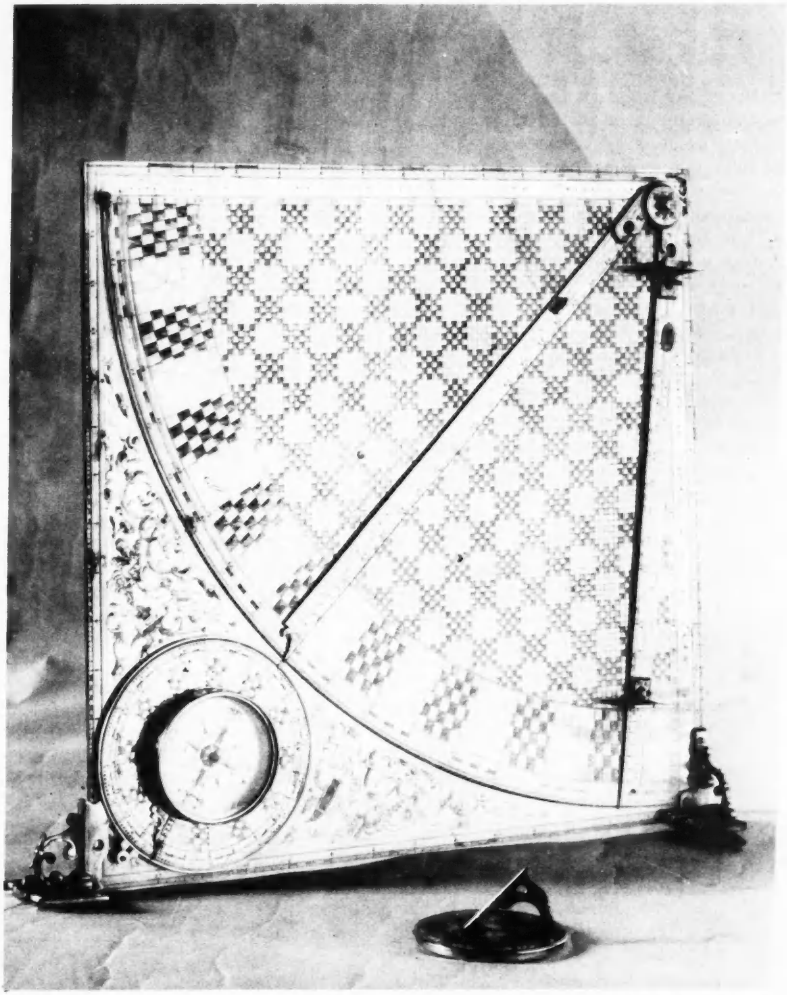


FIG. 5. Geometrical quadrant made by Tobias Volkmer (*fl.* 1582–1626) of Brunswick for the Duke of Bavaria, 1608. It is 36 cm. square and richly decorated with gilt of three colours. The chequerboard effect is a *sinical* quadrant for the direct reading of sines and cosines. *Florence, Museum of the History of Science, item 2465.*

(Figs. 3 to 5 are reproduced by kind permission of the Museum of the History of Science, Florence.)

Museum of Natural Science, was renamed "La Specola"; but the section housing documents on physics was neglected, and the greater part of it was relegated to a room where the inclement weather and the dust might have ruined them completely. From this section, only that part survived which went to furnish the Galilean Tribune, built in 1841, on the occasion of the Third Congress of Italian Scientists.

Andrea Corsini has now reorganised all the original material, together with gifts which have reached him from various sources. He was thus able to open a museum in the new premises in Piazza dei Giudici—in the old historic Palazzo Castellani. This new museum is worthy of its fine tradition. There are several rooms, each devoted to a special science. Optics is represented by Italian, English, French, and German microscopes and also by a lens belonging to Benedict Bregans of Dresden, which was used in the 17th century to make experiments on the amount of combustion in precious stones. There are also 17th- and 18th-century telescopes, and lenses belonging to names famous in scientific circles in the 17th century, such as Evangelista Torricelli, Giuseppe Campani, and Eustachio Divini.

Mathematics, Electricity, Chemistry, and Medicine have each a room; but the most attractive is that occupied by the astronomical and cosmographic collection. Here are an Arabic celestial globe of the year A.D. 1000; the sumptuous armillary sphere, an instrument constructed by Santucci delle Pomarance in the 16th century to show the motion of the heavenly bodies; 17th-century globes; astrolabes—instruments formerly used for observing the positions of the stars (one of these dates back to the time of Charlemagne); and sundials, too. The visitor cannot help but feel that same deep joy which must have inspired those instrument-makers of the past who so lovingly and skilfully combined art with science.

CHEMICALS FOR THE EATING

MAGNUS PYKE, Ph.D., B.Sc., F.R.I.C., F.R.S.E.

Although we live today in a scientific age, surrounded by the products of scientific discovery, our behaviour remains in many respects as unscientific as it was in medieval times. Few topics arouse deeper emotions than the subject of "chemicals" in food. The definition of a "chemical" in this context is not easy to give. The salt, sodium chloride, added to flour in the making of bread does not rank in the public mind as a "chemical", although the calcium carbonate, added as a nutritional supplement in the form of chalk does. A generation ago the sugar, sucrose, used in making jam, was not considered to be a "chemical", although the addition of glucose was thought, by the best people, to be "chemical" adulteration. Today, glucose has rehabilitated itself. Even more subtle is the classification of the vitamin A that occurs naturally in butter, compared with the identical substance added to margarine. It was Molière's character, M. Jourdain, who suddenly discovered that he had been talking prose all his life. Now that it is dawning on people that everything is made of "chemicals", we have had to call the substances added to food for special purposes "additives".

In the application of science to problems of food, two distinct lines of approach have been followed. The first is that of the nutritionist and the doctor. These have investigated the biochemical requirements of the human body and, as a development of such studies, the possible harmfulness of one or other of the components of individual foods. At the same time, a variety of substances have been added to increase the nutritional value of foods. These have included inorganic elements such as calcium, iron, iodine, and fluorine; vitamins covering vitamin A, B-vitamins, vitamin C or vitamin D, and, more recently, amino acids.

The second main stream of scientific effort has been concerned with the improvement of the separate types of food that make up the diet, and with such technological problems as processing, transport, and storage. Many modern applications of chemistry to food have been developed to deal with these problems. Cereal chemists have discovered substances to improve the structure of wheat gluten by which a "bold", well set-up loaf can be produced. Preservatives have been developed to prevent the decomposition of food. Colours have been introduced to enhance its attractiveness. Fat "extenders" have been invented to improve its texture, and flavours have been synthesised to vary its taste.

THE PHILOSOPHY OF FOOD

The difficulty in deciding whether this application of science to food is good or bad arises from the philosophical problem of determining the purpose of food in modern civilised life. To say that the purpose of food is to nourish is not enough. In 1946 Prof. McCance and Dr Widdowson published a report of experiments with a Spartan diet principally composed of brown bread, milk, and vegetables, which had been recommended for feeding the British population during the war. The protests that used to be made when the bacon ration or the supplies of attractive canned goods on "points" became scarce show how wise the administrators of the time were to refuse to accept these scientific recommendations no matter how excellent the nutritional balance of the proposed diet was demonstrated to be. Food must be attractive as well as nourishing. Thus in assessing the possibly toxic effect of a food "additive", or the possibly deceptive influence of a synthetic colour or flavour, its function as an elegant adornment to civilised life must be taken into account. Many of the likes and addictions of modern life may be harmful, but we tolerate them nevertheless.

SYNTHETIC FOOD COLOURS

It is appropriate to start our discussion of food "additives" with colours because at the present time we in Britain are in the process of abandoning what we once prided ourselves on as one of our basic philosophical premises. In the United States, Canada, and some other countries there are official lists of dyes that *may* be added to foods, all others being forbidden. The present position in this country, where we used to assume there was virtue until there was proof of guilt, is that there is a short list of prohibited colours that *may not* be used, but otherwise any colouring matter is permitted. In January 1955, however, the Preservatives Sub-Committee of the Food Standard Committee of the Ministry of Agriculture, Fisheries, and Food recommended that the British attitude be changed and that it be made law that only those dyes specifically authorised be allowed. In a supplementary report this body has given its list of thirty-two synthetic colours:

Ponceau MX	Tartrazine
Ponceau 4R	Naphthol yellow S
Carmoisine	Yellow 2G
Amaranth	Yellow RFS
Red 10B	Yellow RY
Erythrosine BS	Sunset yellow FCF
Rhodamine B	Oil yellow XP
Red 2G	Green S
Red 6B	Blue VRS
Red FB	Indigo carmine
Ponceau SX	Violet 5BN
Ponceau 3R	Violet 6B
Rhodamine 6G	Brown FK
Orange G	Chocolate brown FB
Orange RN	Chocolate brown HT
Oil yellow GG	Black PN

Colour in food is very important. The dairying industry in the United States completely stifled the trade in margarine by having a law passed which forbade the addition of colour to it. The margarine manufacturers sold pound packets each with a pinch of dye in a twist of paper, like salt in a packet of "crisps".

Nevertheless, the fact that the margarine looked like white cooking fat was sufficient to stop people from spreading it on their bread. We judge almost every food by its colour and, whether this be sensible or not, the addition of artificial colouring matter raises a subtle philosophical issue. For example, if a baker colours yellow a cake made without egg in such a way as to simulate a cake containing egg, is he "enhancing the acceptability" of his product and hence, perhaps, contributing to nutritional betterment? Or is he "deceiving the public" by implying the presence of non-existent egg? Or is the cosmetic effect of the dye on the food harmlessly adding to the attractiveness of the object and the general happiness of those who see it in just the same way as the enhancement of a lady's appearance?

Perhaps the answer to the questions depends upon whether or not the dye is non-toxic. All modern synthetic food colours have today been submitted to extreme pharmacological tests for harmlessness. Unfortunately, by looking at the chemical formula of a substance, there appears to be no means of judging whether sooner or later it may or may not be liable to cause chronic degenerative changes or, worse still, the development of tumours. Until 1936 the oil-soluble azo dye, p-dimethylaminoazobenzene, known as Butter Yellow, was on the U.S.A. list of permitted food colours. Then Yoshida in Japan showed it to be capable of causing liver tumours in rats, so it was withdrawn from the group of certified dyes. In fact there is a very close similarity between the chemical configuration of azo dyes known to be toxic, such as Sudan I and Butter Yellow, and some of those used in colouring foods, such as Yellow AB or Yellow OB. Dr Peacock, Director of Research at the Glasgow Royal Cancer Hospital, has been so impressed by this chemical likeness that he has gone to the length of suggesting that the only way to be absolutely safe would be to abandon the use of *all* such colours.

SYNTHETIC FLAVOURINGS

There are a number of other ways in which the chemist can contribute to the attractiveness of food. Whether or not a particular article of diet is eaten may depend on its flavour. If its natural taste is uninteresting, the addition of flavouring matter might cause it to be eaten and thus contribute to nutrition. The problem again arises how to produce a satisfactory aesthetic effect without using chemicals harmful to health. For example, among sweetening agents, saccharine, discovered by Tallbert in 1879, has been used successfully and harmlessly ever since. It is not absorbed, and it passes through the body entirely unchanged. Newer sweeteners, namely, dulcin and P4000, were, on the other hand, found to produce harmful effects in animals when administered over a long period. They have consequently been withdrawn from human use in this country.

PRESERVATIVES

The prevention of food spoilage by the addition of chemical preservatives is as legitimate a field for scientific endeavour as the study of refrigeration, canning, drying, or any other means to prevent loss and to increase the supply of food. Since early times salt, saltpetre, nitrite, and sugar have been used to preserve fish, bacon, fruit, and many other commodities. Other chemical preservatives, however, have been less satisfactory. Some have been found to be toxic. Opinion about others has fluctuated. In Augsburg, Germany, the use of sulphur dioxide was the subject of legislation in A.D. 1400, and its addition to wine was condemned in London in 1600. Today, benzoic acid and this same sulphur dioxide, or sulphurous acid, and their salts are the only "chemical" preservatives officially allowed in foods in this country. Benzoic acid occurs naturally in many fruits and vegetables and up to 0·5 gramme or more can be excreted daily, in the form of hippuric acid, without harm. Sulphurous acid is somewhat more toxic, but its unpleasant taste in higher concentrations is, it is assumed, a safeguard against the consumption of dangerous amounts. These are the rearguard of an army of substances, including borates, fluorides, formaldehyde, and phenols, which have one by one dropped out as their potential dangers have become apparent.

Propionic acid has for some years been known to possess a disinfecting action against spoilage organisms in food. It is a substance that may occur naturally, for example, during the manufacture of cheese. Not long ago a method of preventing mould in rye bread and pumpernickel in Germany was described. This depended on the addition to the dough of a bacterial culture that actually produced propionic acid as the bread was being made. It was, in fact, an antibiotic used as a food preservative. Since that time a number of the antibiotics used in medicine have been suggested for addition for food: penicillin, streptomycin, and others less well known have been claimed to delay deterioration in meat, and aureomycin and terramycin have recently been added to the ice in which fish are preserved. An obvious risk of treating these potent therapeutic agents as food "additives" is that their general use may lead to the development of resistant disease organisms against which the antibiotics would be powerless when employed for medical purposes. The problem of whether this particular kind of "chemical" preservative might have this peculiar toxic effect is beginning to exercise the minds of the medical profession. At present the law does not permit the use of recognised antibiotics as food preservatives, but the Department of Scientific and Industrial Research has already organised trials of aureomycin added to the ice used by trawlers. The quantities employed are very small and residual amounts would probably be destroyed by cooking, but nevertheless some nagging doubts remain.

FAT EXTENDERS

During recent years there has been an increasing use of a wide variety of surface-active agents. These have been used as "fat extenders" in the bakery, confectionery, and ice-cream trades, as anti-staling agents, and as emulsifiers in such commodities as salad cream. These substances fall into two chemical groups, the so-called

polar compounds, such as glyceryl mono-oleate and monostearate, glycol oleates and stearates, pyridinium compounds, penta-erythritol stearate and ethanolamine oleates and stearates; and non-polar compounds of which the polyoxyethylene compounds are the best known. Of these, poly-oxy-ethylene-mono-stearate (called by the Americans, with their flare for abbreviations, POEMS) is the most common. Once again, these substances raise the two problems that we have already considered. The philosophical one: if the addition of glyceryl monostearate to, say, cake, gives the consumer the impression that it contains more fat than it actually does, to what extent is his health and happiness affected by the fact that it contains less? The second problem is whether or not this type of "additive" is likely to be toxic.

It was reported from the United States that the introduction of polyoxyethylene monostearate in 1947 led to a reduction of 2–4% in the amount of fat used in bread and rolls. This represented a diminution of 50,000 tons a year in the consumption of fat. Later, animal experiments showed that the use of this particular fat-extender might cause kidney stones. It was pointed out by the manufacturers that the amount that would need to be eaten by a human being to reproduce the condition of the rat experiments was larger than anything likely to be consumed in practice. Nevertheless, the use of this chemical in America was stopped. Glyceryl monostearate, one of the polar substances, is being widely used. It occurs in nature during the normal breakdown of fats in the body, and no toxicological objection has ever been raised to its use. We are therefore left with the philosophical problem only, and no one appears to worry very much about that.

FLOUR IMPROVERS

There has been interminable, and sometimes acrimonious, public discussion about flour improvers during the last ten years, ever since Sir Edward Mellanby published his dramatic discovery in 1946. He had shown that agene, which is the gas nitrogen trichloride that was used in 95% in all the flour eaten in the country, was capable of producing fits in dogs. By 1950 it had been discovered that the toxic substance was a combination of agene with methionine, one of the constituent amino acids of flour gluten, and that this compound was toxic to monkeys, rabbits, and ferrets as well as to dogs. The use of agene has now been abandoned, although it must be admitted that it has never actually been proved that it is harmful to man.

The reason why improvers are used at all is that people like their bread to be white in colour, and even and open in texture. We all have deep superstitious feelings about bread with its ancient symbolic association as the "bread of life", "our daily bread". The nutritional composition of bread is, of course, important, but in public estimation the symbol of civilisation is the uniform, honeycomb structure, and bland taste and texture of a wrapped and sliced loaf produced in an up-to-date plant bakery. To produce such a loaf under modern conditions, improvers are necessary. Today, chlorine dioxide is used in place of agene, together with potassium bromate or potassium iodate.

NUTRITIONAL SUPPLEMENTS

The iodine-containing substance, potassium iodate, is used in flour because of the technical effect it exerts on dough structure. Iodine-containing salts have, however, been used for a very long time as additives designed to improve—not the physical quality of the diet, but its nutritional value. The addition of iodine to domestic salt is very widely practised in this and other countries as a prophylactic against goitre.

The use of mineral salts and vitamins as "chemical" additives is based on two lines of thought. The first of these is a *belief* that some article of diet, usually bread, ought to contain some arbitrary amount of this or that vitamin. The usual argument is that white bread ought to possess the same vitamin value as bread made from wholemeal flour, although few people seriously suggest that it ought to contain as much indigestible residue, and no one has ever suggested that sugar ought to contain the same vitamin content as whole ground sugar cane, although a strong nutritional case could be made for its doing so. The second motive behind the addition of nutrients is to bring up the nutritional value of the total mixed diet eaten by the average member of the community, or by some special fraction of it—the poor, or the young, let us say—to a level known to be adequate for full health.

The second approach has led to a number of excellent and valuable public-health measures: the addition of vitamins A and D to margarine is one. But even this benevolent use of additives would appear to require some scrutiny. It seems reasonable to argue that an adequate diet can best be achieved by the consumption of an appropriate *variety* of foodstuffs not containing additives. Deficiency of vitamin B_1, if this argument is valid, can be escaped by avoiding an excessive intake of white flour and sugar-pastry, jam and buns, for example. Shortage of vitamin C will not occur if potatoes, fruit, and vegetables are included in the day's menu, and so on. It is true that in many instances "you can't have too much of a good thing". In some cases, however, you can. There is reason to believe that the enrichment of dried milk, margarine, and certain other foods with vitamin D may be causing children to consume more vitamin D than is good for them.

GOOD SENSE

It is a difficult and dangerous business to live a complete and civilised life in the modern world. As civilised people we demand sophisticated adjuncts to our food, whether they be flour improvers, azo dyes, or artificial flavourings. It has been said with some degree of truth that anything worth having in this world is either "illegal, immoral, or makes you fat". The problem of controlling the use of additives designed to improve the technical quality of food must be solved by good sense in deciding how much risk is worth taking to enjoy any given pleasure. For example, many people are prepared to smoke cigarettes even though they know that by

doing so they are increasing the risk of contracting lung cancer.

The use of good sense is even more important in regulating additives intended to improve nutrition. The desirable vitamin and mineral content of bread must be determined by the proportion of bread in the total diet and the composition of the other items eaten, and also by the needs of the people eating the diet. How difficult it is to prevent emotion swaying good judgment is exemplified in the instance of fluorine. It has been shown that the addition of appropriate very small amounts of sodium fluoride to drinking water reduces the incidence of tooth decay. Twenty-two million Americans in 1123 towns drink artificially fluoridised water. In December 1955 the results of a ten-year controlled experiment in New York State showed that in Newburgh, where the water had been treated, children between six and nine years old showed 58% less, and between ten and twelve years old 52% less dental decay than in neighbouring Kingston, where the water was untreated. In England the Medical Research Council has made similar observations and shown that there is no ill effect in adding sodium fluoride to water. And yet here as well as in America the elemental human clash between *thinking* and *feeling* has resulted in strange but nevertheless violent attacks on fluorine as an additive. It seems that when chlorine is added to drinking water it is a familiar friend. Fluorine, however, is a "chemical".

Controls there must be. In Britain there exist the Food Standards Committee of the Ministry of Agriculture, Fisheries, and Food; the Food and Drugs Act; and the Common Law. But behind all these there must also be common sense.

OPERATION BUFFALO

CHAPMAN PINCHER

Operation Buffalo was the largest and most ambitious series of atomic weapons tests yet attempted by Britain. Four devices were successfully exploded between September 27 and October 22. These included the first air-drop of a British atomic bomb, the first ground-burst of such a weapon, and the first really detailed assessment of the powers of an atomic weapon when used against military targets and civil defence structures.

As a member of a small party of Press observers, I was privileged to witness one of the explosions from a distance of only about six miles and to fly low over the devastation shortly afterwards. In addition, I was able to inspect the greater part of Maralinga, the £6,000,000 facility set up in the desert 600 miles north-west of Adelaide as a permanent atomic proving-ground.

The complexity of the organisation required for such tests impressed me even more than my first really close-up view of an atomic explosion. A large village of prefabricated hutments, laboratories, power plants, and all the domestic facilities required to support an operation involving more than 1200 men has been set up in an area previously considered unfit even for aboriginals to live in. There is a well-equipped airfield with an 8000-ft. runway, long enough to take jet-bombers. Scores of miles of roads capable of carrying tanks and the heaviest trailers have been bulldozed out of the red-clay desert. In addition, a temporary tented encampment was set up for Operation Buffalo to accommodate the 250 Army officers who were to be "indoctrinated" into the effects of tactical atomic weapons.

The first test was delayed for sixteen days because of the extreme precautions imposed by the safety requirements. Obviously no risks could be taken which might expose civilians, stock, or land to any dangerous degree of radioactive fall-out, but special political difficulties made the safety restrictions at Maralinga more than usually stringent.

Since the unfortunate incident in which a Japanese fishing-boat was showered with fall-out from a U.S. hydrogen bomb, Australian objection to the use of any part of the Australian continent or territorial waters for testing atomic weapons has stiffened. The Australian Labour Party leaders are exploiting this development by promising to ban atom tests if they are returned to power. It was therefore vital to the existing Australian Government which permitted the use of Maralinga, and to the British who want to retain it, that there should be no "incident" of any kind. This meant that no trace of radioactivity, which might be entirely harmless but nevertheless could be detected by Geiger counters, should drift over any major city, thereby touching off scare stories in the Press and Parliament.

FINAL PREPARATIONS

The first bomb was set up on a steel tower about twelve miles from the intricate control centre from which the operation was directed and the weapon finally fired.

Military targets of every kind—Centurion tanks, guns, radar sets, airplanes, fuel-tanks, ammunition, and explosives had been set up to determine how they would stand up to the blast, fire, and radiation. Dummy men dressed in Army uniforms and anti-flash suits were set up in the path of the explosion. Civil defence scientists had erected sections of houses, bridges, factories, aircraft runways, and shelters of various types, civilian clothing, foods, medical supplies, paints, rubber, paper—almost every kind of material found in a modern city—were dispersed in the target area.

In addition, sheep, goats, rabbits, and mice were stationed in the area for civil defence, agricultural, and medical research. Some, penned behind heavy structures, were exposed to blast and to radioactive fall-out. Most were used for feeding experiments in which they were given contaminated herbage.

Automatic cameras and other recording devices were focused on many of the individual targets to provide permanent records of how they behaved in the first few

moments of the explosion. The bomb itself was the focal point of scores of cameras, blast-recorders, and telemetering devices. In complexity these ranged from extremely expensive cameras taking a hundred thousand pictures a second to toothpaste tubes blown up with air. (Blast waves from the bomb compressed the toothpaste tubes, and the amount each was deformed enabled the scientists to calculate the force of the blast at different distances.)

When the Press party first landed at Maralinga airfield at 4 a.m., on what the troops there called a "six-blanket" night, the operation, aimed at detonating the bomb at 7 a.m. was already well advanced. Convoys were taking scientists out to the target area for the final testing of the recording equipments and the loading of the cameras. The animals were being placed in position.

To the left of the control centre, in a clearing marked "Circus", was the Health Control group, a collection of large caravans with tall twin chimneys. These vehicles—the prototype of an Army decontamination centre—contain shower-baths, monitoring equipment, protective clothing, and medical supplies. They were to move up to the edge of the radioactive area after the bomb exploded, just as they would on a battlefield.

The control centre itself, which we were allowed to inspect for the first time, is a much more complicated set-up than is generally imagined. There is a large console with clocks, dials, illuminated screens, and buttons for firing the weapon. A large magnetic board with movable units representing men and machinery enables the director to keep an up-to-the-minute check on every party on the range. As each party reports back over the telephone and walkie-talkie network, its position on the board is moved.

As a further check, each party in the danger area has a key. Until all the keys are in locks fitted in the firing control panel, the weapon cannot be detonated.

Finally, the party which arms the bomb at the tower and is the last to leave the area carries a master safety link which must also be inserted in a socket on the control panel. The word "Armed" appears on a ground-glass screen when the bomb is ready for detonation. Dials and meters show whether the firing circuits and main recording instruments are working correctly. Then, after final wind-tests with meteorological balloons, the director and safety committee give the go-ahead and three buttons are pressed to set the firing mechanism in motion. This can be stopped within one-tenth of a second of zero-point.

The first time we flew to the site Sir William Penney, the director, cancelled the test within thirty minutes of detonation time. A plane-load of Australian politicians, including several of the anti-atom-bomb Labour members, had arrived after flying all night. Their doubts about whether the fullest safety precautions were being observed were quickly dispersed. Sir William Penney announced over the loudspeaker that because the winds were not *exactly* what he wanted the whole test would have to be postponed even though it would disappoint the politicians.

Later the test was to be postponed within *five minutes* of zero-time when the wind changed forty degrees in half an hour. Eventually, though a dawn explosion was preferable, Sir William decided on a 5 p.m. blast to snatch the advantage of a spell of settled weather.*

THE EXPLOSION

By that time we were stationed on a ridge about a mile from the Army "indoctrinees". (Originally it was intended that we should be with them but authority decreed that the Press should not be in a position to observe if any indoctrinee fainted!)

We faced away from the blinding flash—officially described as about a hundred times brighter than the sun—and turned to see the first fantastic stages of the fireball.

The few pounds of cold metal in the bomb had swelled to a huge red and yellow hemisphere which sat momentarily on the desert, then shot upwards at a speed of more than 100 miles an hour like a balloon seething with flame and turbulence. Rockets streaked through and behind it leaving smoke-trails, which when photographed helped to measure the shock-waves.

Momentarily the fireball, which seemed much nearer than six miles, was capped with a purple haze caused by the intense radioactivity equal to about a million tons of radium.

Half a minute later the shock-wave and thump of the explosion swept past us. The impact of the shock-wave was much less than I had experienced when witnessing a previous bomb three years ago from a distance of thirteen miles. This was simply due to the terrain. The staff at the control centre farther back felt the shock-wave. So did the pilot of the Canberra bomber, Group Capt. S. W. B. Menaul, who flew through the cloud to collect fission products for immediate analysis.

Rising rapidly, the churning debris, which had ceased to be luminous within ten seconds, towered up in front of us into the familiar mushroom loaded with peach-brown nitrogen peroxide.

Almost immediately the first scientists started probing the area with their Geiger counters feeling their way towards the cameras which must be unloaded before the gamma-radiation from the fall-out fogs the films.

Within an hour I was flying over the target at 500 feet seeing the effects of the weapon which is believed to have been of the same power as that exploded over Hiroshima—a "few tens of kilotons".

Scores of fires were raging as far as two miles from the huge grey scar which marked the place where the tower supporting the weapon had vanished in a flash of vapour.

Army hutments set in the path of the blast had been reduced to heaps of wood and metal splinters. The Centurion tanks were smoking. Three out of six Swift jet-fighters sacrificed as targets had capsized.

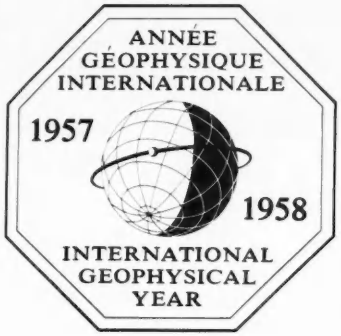
It was hard to escape the illusion that this was a desert battlefield with men and machines utterly devastated by one tactical weapon.

* On the two mornings when the test was postponed only a few minutes before zero-hour a flock of galahs—parrots with legendary reputation for extreme stupidity—were said to be flying round the bomb tower. On the day the weapon really went off there was not a galah to be seen.

THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome



British Expeditions Sail

The *Magga Dan*, the 1650-ton new Danish polar-ship, sailed from Butler's Wharf, London river, for the Antarctic on November 15 with the twenty-one men of the Royal Society main expedition party and the sixteen men of the Trans-Antarctic expedition aboard. All but two of these men will be away for two years or more. Colonel Robin Smart, leader of the Royal Society expedition, has leave of absence from the War Office for only one year, and George Hemmen, expedition stores officer, will return with *Magga Dan* next spring.

As *Magga Dan* could not accommodate the passengers and all the equipment needed for two seasons, the *Tottan*, last year's expedition ship, was chartered at short notice to take the rest of the Royal Society party's stores. She left London soon after *Magga Dan*, and it is hoped that she will reach Halley Bay as the first ship completes unloading. The expedition expected to enter the pack-ice of the Weddell Sea shortly after Christmas and to reach Halley Bay early in the New Year. Stores and equipment for the whole period of the stay at the base are being taken this year in case the base cannot be relieved next season.

Of the thirteen IGY disciplines, six are to be studied at Royal Society Base. These are: Meteorology (II), Geomagnetism (III), Aurora and Airglow (IV), Ionosphere (V), Glaciology (IX), and Seismology (XII). The scientific team is made up of five meteorologists, three ionospheric physicists, two radio-astronomers with distinct programmes, and an aurora expert—eleven men in all. In support are two radio-operators and two diesel mechanics.

The main object of the meteorological work will be to ascertain the mechanism whereby air masses are exchanged between the tropics and the Antarctic region. The meteorological group will also operate the seismic apparatus, and they hope to gain evidence of how seismic waves travel from a centre in the Andes (though this may prove too far for their modest equipment) and from a position in the South Atlantic.

Two of the most interesting experiments to be undertaken are those of the radio-astronomers. One is to study the diffracting effect of the ionosphere on waves from an intense radio source in the constellation of Centaurus. The other will observe the ionisation caused at a height of 100 km by both meteoric and auroral particles, using a radar beam which sweeps the sky every five minutes while a film records the image on the screen. The technique is similar to that used at Jodrell Bank. Both these observations will be carried on throughout the twenty-four hours.

The Trans-Antarctic expedition are to take the opportunity of the continental crossing to carry out a seismic traverse and a gravity traverse of the ice-cap. Other glaciological and various meteorological records will be kept.

Watching the Wind

The first radar apparatus specifically designed for meteorological wind-finding was the heaviest piece of apparatus among the many scientific instruments embarked aboard the *Magga Dan* for operation by the Royal Society expedition at Halley Bay, Antarctica. It weighed 1½ tons—and even so was light for the job. It has been developed by Decca, pioneers in the application of radar to meteorological problems. The equipment has been operated to as high as 30 kilometres (at which point the balloon carrying the foil target-reflector burst). It is said to be equally effective at height in jet stream conditions and for low-speed winds at limited altitudes.

Up till now adapted military radar has been used for wind-finding—a costly and rather a clumsy expedient. The use made of radar in wind-finding is almost the reverse of its orthodox use since here a "given" target must be held in focus.

The instrument is used with standard radiosonde flights; one balloon carries aloft both the sonde and the foil radar target. The 2·5 metre "dish" acts both as transmitter and receiver; the central antenna is spun to describe a cone of 1° which therefore gives directional information within a cone of 2°. The apparatus requires two operators, one to keep the dish on target, the other to take the readings.

Duke of Edinburgh in the Antarctic

On his way back from his Australian tour, H.R.H. the Duke of Edinburgh is to spend a week touring British Antarctic bases in the Falkland Islands and Dependencies. He will arrive at the Deception Island base in the Royal Yacht *Britannia* on January 1. There the yacht will be met by HMS *Protector*, the Navy's Antarctic patrol ship, and the newly built RRS *John Biscoe*, whose first Antarctic season this is. If sea-ice conditions permit, *Britannia*, with the Duke on board, will proceed south to the Danco Coast base and Port Lockroy. Here the Duke will transfer to the RRS *John Biscoe* and, with *Protector* as escort, will proceed still farther south, to the Anvers Island base and the Argentine Islands. If ice conditions are bad, the Duke will make the whole journey from Deception Island in the *John Biscoe*. Sir Raymond Priestley, at present Acting Director of FIDS Scientific Bureau, has joined the Duke of Edinburgh on *Britannia* and will accompany him throughout the Antarctic tour.

On completion of this tour the Duke will return to Deception in the *John Biscoe*, where he will rejoin *Britannia* and, with the two other ships in escort, will sail to Port Stanley, the chief town of the Falkland Islands. The Duke is expected to reach Deception on the return journey on January 5 and Port Stanley on January 7.

Contact with Antarctic

Shackleton, the trans-Antarctic expedition's base on the Weddell Sea, was in direct radio communication with London last October for the first time since it was established. Royal Society Base achieved contact last March, though only intermittently since. Shackleton is the other side of the auroral belt in relation to London, while Halley Bay is on our side. Because the auroral belt lies between them, Halley Bay and Shackleton, only 220 miles apart, have not yet established satisfactory radio contact with each other.

***Protector* Achieves a Record**

Two men and their dogs were rescued in November by HMS *Protector* from Roux Island, 66° 54′ S., 66° 58′ W., in the Weddell Sea. With the equipment and the specimens that accompanied them, they were hoisted by winch into a helicopter from the ship and then returned to their FIDS base on Lent Island. They had been marooned for more than three weeks. The S O S reached *Protector* when she was several thousand miles away, at Rio de Janeiro.

In order to get within helicopter range of Roux Island, *Protector* had to venture some distance south of the Antarctic Circle into the Weddell Sea. This is believed to be only the second time the Antarctic Circle has been crossed during November in the

Weddell Sea area. The previous occasion was also on November 9—in 1843.

Antarctic Exhibition

An exhibition to mark the departure of the two British expeditions to the Antarctic continent is on view in the Mineral department of the Natural History Museum in Cromwell Road. It is quite a shock to realise how young Antarctic studies are, but also how much excellent work was done by the early explorers under the bleakest conditions. A hundred years ago the existence of an Antarctic continent was still in doubt. In 1849 members of Sir James Ross's *Terror* and *Erebus* expedition captured several Emperor penguins whose gizzards contained stones of unmistakably continental character. This crucial evidence escaped notice at the time, but the stones are at the museum to bear witness today. They are displayed with a diorama showing *Terror* and *Erebus* alongside the ice-shelf.

In 1874, when *Challenger* dredged up a *gneiss* boulder from the Southern Ocean bottom it was recognised as evidence of a southern continent. Also in the exhibition are rock specimens that Dr Wilson insisted on retaining on the sledge to the bitter end of Scott's last expedition, and the only meteorite so far found in Antarctica. This was recognised by members of Mawson's 1912 Australasian expedition in Terre Adélie.

Australians' Winter Operations

The Australians claim that they have put up an Antarctic record for the amount of exploration carried out during a South polar *winter* season. A flying programme was even maintained from Mawson during the two months when the sun does not clear the horizon, aircraft being picketed and servicing maintained in a special hangar which is said to be the first of its kind in Antarctica. Ground temperatures were comparatively mild this year, with the thermometer usually about −23°F; but at 18,000 feet temperatures in the aircraft often fell to −56°F.

During May a new depot was laid at King Edward VIII Gulf, 170 miles West of the main base. This operation was carried out by air using both the expedition's *Beaver* and *Auster* aircraft. Scientists were also transported by air to investigate the coastal region in preparation for spring operations. A new Emperor penguin rookery which had been observed from the air at Stefansson Bay was visited by two of the expedition's biologists. Altogether eighty flying hours were logged in nineteen missions during May.

During June and July, undeterred by the almost perpetual darkness, men from Mawson pushed on with fieldwork by dog-sledge and *Weasel*. The Douglas Islands, the Stanton Group, and the Taylor Glacier region, all within sixty miles of Mawson, were explored.

During August the RAAF Antarctic Flight studied two widely separated regions: Enderby Land 300 miles to the west, and the Prince Charles Mountains, 300 miles to the SSE. In Enderby Land many new peaks and unmapped coastal features near Cape Anne and Amundsen Bay were revealed and photographed. The flight to the eastern extremity of the Prince Charles Mountains showed that a great gulf extends from Prydz Bay westward to the mountains. That this might be so was first suggested by Philip Law, Director of the Antarctic Division, when he was exploring in this region in 1955.

During September another 105 flying hours were logged by Mawson's two aircraft.

In November four Australians headed by the Darwin Meteorological Officer, were conveyed by an American expedition from New Zealand, to Windmill Island, 1000 miles east of Mawson, to set up an automatic weather station. They will radio information, wind pressures, and temperatures twice a day to Perth and Hobart through the IGY.

The Australian party will be taken off by *Kista Dan* on her way to Mawson later in the season.

Water in an Antarctic "Oasis"

Several so-called "oases" are known on the Antarctic continent. Vestfold Hills, where the Australians will set up their second base, is one. The "Bunger oasis" (so named by the U.S. 1946–7 expedition), which recently became the site of the third Soviet base to be established in the Antarctic, is another; it is near the coast, 250 miles from Mirny, and consists of over 300 square miles of bare rocks interspersed with lakes. There is a third in the Neue Schwabenland area of Queen Maud Land, investigated by the German 1938–9 expedition.

After reconnaissance of the Bunger region by thirteen Soviet scientists last January, the U.S.S.R. Academy of Sciences published a report, "Geographical Observations in an Antarctic 'Oasis'." The puzzle of such areas is how, where there are furious blizzards in winter and temperatures that scarcely rise above freezing in summer, there can be ice-and-snow-free rocks and water in the lakes in summer. Various explanations—hot springs, volcanic heat, underground coal fires, radioactivity—have, at different times, been proposed. The Russians favour the explanation originally put forward by the 1948 American expedition's geologist, and the opportunities they will have for testing their hypothesis should certainly provide the proof.

The oasis is right on the coast which is bordered by permanent sea-ice. Inland the area is surrounded by land-ice, and two big glaciers, the Scott glacier and another which has been named (by the Russians) the U.S.S.R. Geographical Society glacier. The two glaciers are diverted round it by deep valleys underneath. This prevents the huge ice-masses from encroaching on the area. During the winter, strong winds sweep away the snow as it falls. During the summer the sun beats down on the bare outcrops of dark-coloured rocks, melting ice and surrounding accumulations of snow. Melt-water and the warm surrounding rocks raise the temperature of the lakes so that some of them become completely free of ice. The air is extremely dry and moisture evaporates very quickly.

In a recent press interview, V. Burkhanov, chief administrator for Soviet Antarctic affairs, characterised the Soviet Oasis base as situated by "a 'thaw-hole' in the Antarctic's armour". The area has its own "micro-climate", he said. Observations from this area would be of particular interest. The base's weather-station began functioning in mid-October.

Lowest Antarctic Temperature

The lowest temperature ever recorded in the Antarctic was registered during the winter season just past at the Soviet satellite station of Pionerskaya. The reading was −66·8°C (or −88°F), recorded on September 20, 1956. The previous record, of −60·2°C was held by the 1934 U.S. expedition. This is not, however, the absolute lowest ever recorded on earth; −69·8°C has been recorded at Verkhayansk, and −67·7°C at Oymekon, both in Siberia.

Pionerskaya is the second of the two Soviet bases established last summer season. It is about 230 miles from the coast and stands on the inland ice plateau 8850 feet above sea-level.

South Pole Landing by the U.S.

On November 1, 1956, an American transport aircraft touched down at the South Pole. Out of it stepped seven members of the U.S. "Operation Deepfreeze" including Rear-Admiral George Dufek, operational commander of the U.S. Antarctic expedition. These are the first men to stand at the Pole since Scott and his four companions trudged north to die forty-six years ago. It was the first time an aircraft landing has ever been made there.

The aircraft landed on a surface of hard, dry snow and remained down for forty-nine minutes before making a jet-assisted take-off. The party left behind embedded in the snow a trail of flags and radar reflectors for the assistance of future landings. A U.S. Air Force Globemaster was in support during the visit, and later in the day another U.S. aircraft dropped supplies and an automatic weather-recording device. The Americans have now established an IGY station on the South Pole by airlift. To reach the site, aircraft have to clear the 15,000-foot mountains on the way.

More Rocket News

On October 10 an American four-rocket-stage research vehicle achieved the height of 200 miles at a record speed of 6864 m.p.h. It was launched

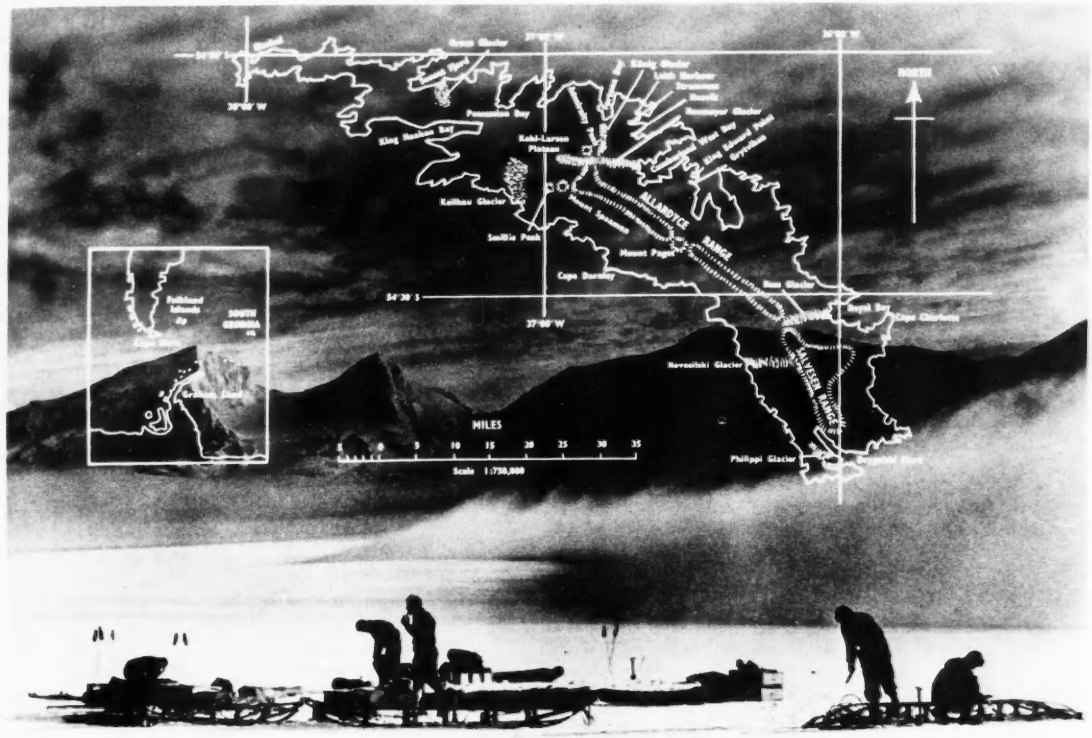


FIG. 1. The island of South Georgia, which lies a thousand miles east of Cape Horn. For almost 180 years, since the first landing of Captain Cook in 1775, this forbidding island of glaciers and snowfields has remained virtually unmapped. In 1951, however, the first of three survey expeditions led by Mr Duncan Carse began the task of mapping. The three surveys were made by small parties of six, four, and eight men, who had to man-handle all their supplies and equipment by sledge. Not until May of this year was the final survey completed. (*A Shell photograph.*)

FIG. 2. Scraping ice from the sledge runners before leaving camp in South Georgia. The sledges were coated with varnish based on "Epikote" resin, a petroleum-derived product; this protected them against the severe weather and extreme hard wear. (*A Shell photograph.*)

FIG. 3. Photographic and radio-tracking instrument for "Skyhook" balloons, to be used for exploration of the upper atmosphere during the IGY by the Naval Research Laboratory of the United States.

from Langley Field, Virginia, over the Atlantic, under the auspices of the U.S. National Advisory Committee for Aeronautics. The rockets were fired in sequence; the first two were similar to the Nike rocket.

Mr Floyd Thompson (associate director of research at the Aeronautics Advisory Committee's laboratory) mentioned the earth satellite in a statement about the flight; he also implied that the experiment smoothed the way for inter-continental ballistic missiles flying at 13,200 m.p.h. and space-craft travelling at more than 20,000 m.p.h. The first test vehicle for satellite launching was fired on December 8 and reached 4000 m.p.h. and 125 miles high.

The first tests of Britain's "Skylark" rocket, which has been specially designed as a research vehicle for the IGY, are expected soon at Woomera Range. At present five main research projects are envisaged. These include the explosion of grenades to yield information about atmospheric pressure, temperature, and wind, and the ejection of sodium vapour to provide another means for similar determinations at greater heights. Later potassium may be used to produce a fluorescent "cloud" in the same way.

The British rocket uses solid fuel for economy, is a single-stage vehicle which will at first reach 150 kilometres (about 90 miles), but is expected to achieve 200 kilometres later. It has no stabiliser, which means that once it is in the air it is uncontrolled. This is one reason why it will first be fired in the Australian desert. If it behaves well there, firings will be scheduled from the United Kingdom also, during the IGY period.

The Japanese also decided to join in the IGY rocket programme two years ago. They had to make a choice between co-operating with the United States' rocket programme or developing a Japanese rocket of their own. They decided to do the latter; their rocket, the "Kappa", made its first flights this August. This was a single-stage rocket reaching up about thirty miles. The Japanese hope next year to fire two- and three-stage rockets similar to the U.S. "Aerobee" with ranges of 80 kilometres and 110–120 kilometres respectively.

Optical Tracking Plans for U.S. Satellite

Some time after July 1, 1957, the U.S.A. will launch a 20-inch sphere, its orbit inclined at less than 40° to the Equator, with a perigee of about 250 miles, apogee of 1000 miles, and a consequent period of revolution of 90 to 100 minutes.

The satellite is being built and launched under the direction of the U.S. Department of Defence. Once in orbit it becomes the responsibility of the Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, to track the satellite both visually and photographically. Tracking of the satellite involves two programmes besides the radio-tracking system. One is concerned with visual observations, which will be made by teams of experienced, volunteer observers spaced across the United States. It is hoped that similar stations will be organised in other countries also. The other programme is the photographic tracking project to be carried out by twelve to fifteen stations around the world, each equipped with specially designed Baker-Nunn Schmidt cameras to provide precision measurement of the satellite's position. The specially designed telescope will have a 31-inch spherical mirror, and a triple correcting plate of 20-inch diameter. It will be able to track the satellite and the background star field alternately. A built-in timing device will record time photographically to one ten-thousandth of a second and will maintain an accuracy of one-thousandth of a second. Such precision is essential for the full use of the satellite as a scientific vehicle.

The visual observation teams will furnish data for the calculation of ephemerides necessary for operation of the cameras at the photographic stations. Each member of a visual observation team will be assigned an instrument fixed in position along the meridian and will be responsible for observing only a relatively small section of the meridional sky. Passage of the satellite through the field of one, or possibly two, of the instruments (monoculars or binoculars) could be timed by stop-watch methods or by the auditory reception of radio time signals. A team leader will supervise the observation programme. He will transmit observed data by telephone, telegram, cable, or other such speedy means to the computing centre located at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts.

Volunteer visual observation teams have been organised throughout the United States. It is expected that the total will reach nearly 200. Meanwhile the teams will participate in practice sessions (some nationwide) to test techniques, communications, and organisational aspects of the visual observation

programme; these so-called "alerts" will be held from time to time until the satellite is in orbit.

The visual observing corps will be extremely useful, and indeed essential, in both the early and the late stages of the existence of the satellite. In the early stages they could substitute for the U.S. Naval Research Laboratory's Minitrack radio system within the satellite if the device should fail to broadcast signals, and the visual observers will be invaluable during the last several revolutions of the satellite just before its disintegration as it spirals down into denser atmosphere. In these last stages the radio-signals system is not expected to operate, the life of the battery being too short; the data obtained by visual observers will thus be the only source of information in these last few revolutions of the satellite, when the orbital changes are expected to be so great that the more elaborate and precise observational techniques cannot be depended upon.

It will be important to have visual observer teams as well as photographic stations situated around the world. The photographic stations will be relatively few in number and widely separated around the satellite belt. In the United States, as in other IGY countries, the visual programme is under the direction of a co-ordinator. Amateur astronomers and other technically inclined persons who wish to make serious visual observations of the satellite might communicate with a Co-ordinator of Satellite Observations in their own countries. Visual observation and all other data obtained in each country will be forwarded to the Smithsonian Observatory only through the official co-ordinator in that country.

"Skyhook" type of balloon which will float above the ocean when a solar flare is expected. When a radio signal from the ground fires the rocket, it is expected to reach an altitude of 65 miles above the earth within 105 seconds of firing the signal. The rocket will contain instruments for measuring the strength of x-rays and ultra-violet radiation from the flare.

Volunteer visual observers will be committed to a schedule requiring considerable expenditure of time and effort, not to mention inconveniences and sacrifices of varied descriptions. Simulated watches will be held in the coming winter months in the United States. All of them will be out of doors at only semi-protected sites and they may be extremely uncomfortable. The watches, whether simulated or actual, must be stood in the dawn or evening twilight hours. Watches at any specific station will occur a few times per month; and the term of service will extend over several months as successive satellites are fired into orbit. Most of the volunteers will furnish their own instruments. That the volunteer visual observers are dedicated persons is obvious; that already more than 1000 have joined the programme is gratifying evidence of wide interest in it and in science itself.

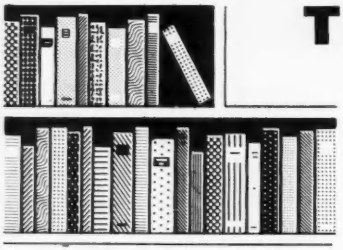
IGY Fellowships

To ensure a sufficient supply of trained specialists for the IGY's world-wide activities, UNESCO has financed and organised eight fellowships. Their distribution has been arranged in conjunction with the Secretary-General of CSAGI. Fellows have been elected from each of the following countries and most of them are already undergoing their training: Argentina, Bolivia, Chile, Egypt, Pakistan, Peru, Thailand, Yugoslavia. The following institutions are providing the courses: The Institute of Meteorology, Charlottenlund; The California Institute of Technology; The U.S. Weather Bureau, Washington; The National Bureau of Standards, University of Colorado, Boulder; The U.S. Coast and Geodetic Survey, Carnegie Institution of Washington.

TWENTY-FIVE YEARS AGO

Two items from the January 1932 issue of DISCOVERY are of special interest to us twenty-five years later. One is an article on "International Polar Research", by Frank Debenham, then Director of the Scott Polar Research Institute, and it describes plans for the Second Polar Year (1932–3): "The Polar Year is to be the means of the simultaneous investigation of the following problems: the general circulation of the atmosphere in Polar regions, both at ground level and in the upper atmosphere . . .; terrestrial magnetism and the aurora." In England, special interest centred round the expedition to Fort Rae, a settlement of the Hudson Bay Company on the northern arm of the Great Slave Lake in lat. 62° 50′ N., near one of the two "Poles of Cold" in the Northern Hemisphere, the other being in Siberia. The article deplores the fact that world-wide financial depression made it necessary to cut down the expenses for the Polar Year severely.

The other is an article by Sir Henry (then H. H.) Dale, urging the need for a wider popular interest in biology. He says: "Science, I suppose, has so far won its long battle for recognition in the schools as a cultural factor, that the majority now offer an opportunity to all their students for acquiring some knowledge of mathematics, physics, and chemistry. Biology, on the other hand, where any provision at all is made for its teaching, is hardly ever a part of a normal curriculum. An intelligent appreciation of the fundamental facts of biology is not yet regarded as a necessary part of the equipment of an educated man. On the contrary, it is seldom that any serious teaching in biological subjects is provided in the school for any except those who need it least, from the point of view of a balanced education. The present need is great; but the greatest problem of all lies in the future. The young but brilliantly progressive science of genetics has already brought order and direction to the selective breeding of animal and plant races, fitter for the use of man. It penetrates ever more deeply into the minute cell mechanism, through which competing parental potentialities become effective or hidden in the offspring, or altogether lost. The question becomes insistent, whether man in the future will be able to use such knowledge for the general improvement of his own species, or will continue to reproduce his race under the sole guidance of taboos and traditions which come to him with the force of social, moral, and religious laws. . . . It may be that our far descendants, looking back on the imposing technical structure which we are building on the pure science of Faraday and Maxwell, and on all the achievements of our medical science and biology in making life longer and easier, will regard us with amazement as men who could find no greater use for science than to make the best of the world for the human race as we found it."



THE BOOKSHELF

Learning and Instinct in Animals

By W. H. Thorpe (*London, Methuen, 1956, 493 pp., 55s.*)

In the last few decades great and stimulating advances have been made in the study of animal psychology. These advances have occurred because experimental investigations have pushed theoretical speculations into the background. One problem in particular has recently stimulated many workers; it can find a solution only by experiment. It lies in the question: which types of animal behaviour are based on innate instincts, and which derive from individual experiences and from learning processes? W. H. Thorpe has devoted his book to this particular problem.

The first two parts of it are an introduction to the subject and a description of fundamental concepts as well as their historical evolution. In particular, the concept of instinct has often changed its connotations. Instincts are not always completely formed at birth, and may appear only slowly, in a process of maturation. For this reason alone they are difficult to investigate and to distinguish from learned behaviour. Learned behaviour, properly speaking, can be divided into a number of categories, from familiarisation with repeated stimuli, to insight behaviour. Thorpe has tried to define these categories and to limit them, but the result does not always seem entirely satisfactory. One becomes aware of the very great difficulties which arise from the fact that Nature does not recognise any well-defined boundaries.

In the general part of the book many excellent examples reinforce the theory. The second and more experimental section records a large number of observations and experiments, arranged in systematic order from protozoae to mammals. The immense amount of available material, of course, makes a complete survey impossible. The author therefore confines himself to a discussion of examples characteristic of each group, which are helpful in illustrating general principles. He often goes beyond the narrow subject: he discusses, for example, the performance of sense organs as the basis of instinctive behaviour.

The point is several times made that the classification of a specific behaviour is not possible yet, because decisive experiments have not so far been carried out. It is a great achievement of Thorpe's that he makes us aware of the many gaps in our knowledge. All of us who work on animal psychology will be grateful to him for the excellent survey of existing knowledge and his suggestions for future investigation. We deeply appreciate the amount of work which lies behind the book.

KARL VON FRISCH

The Sexual, Marital and Family Relationships of the English Woman

By Dr Eustace Chesser (*London, Hutchinson's Medical Publications, 1956, 642 pp., 75s.*)

Many people in this country were greatly interested in the Kinsey Reports. Professional and lay people alike wondered how far the findings were applicable to conditions in Britain. In Dr Chesser's report we have the first answer. Dr Chesser and his team of collaborators have set out the results of an inquiry, from a sample of single and married English women, designed to discover their attitudes towards marriage and sex relationships and to relate those to childhood experiences. As in all such surveys, the greatest difficulty was to find a typical cross-section of English women. The sample was selected at random by general medical practitioners who co-operated, handing the questionnaire to their patients. It was found that those who completed the forms and returned them tended to be from the higher-income groups and the more intelligent members of the community. This is always a disadvantage of the questionnaire method: no matter how simple the questions and answers are, several pages of them are off-putting to the less intelligent woman.

The investigations are particularly concerned with how happiness in marriage is related to early family background, to parental and sibling relationships, type of upbringing and discipline as children, sex education, religion, happiness in childhood, age at marriage, and agreement with husband on practical issues. Dr Chesser acknowledges his debt to Terman, who was the first to conduct such a survey, but Terman included husbands as well as wives. There are few new facts which emerge from the Report. The most constant finding is that happiness in childhood and marriage seems to be affected more by parental relationships than by any other single factor. There seems to be no significant association between marital happiness and parental separation and divorce as such, although loss of the mother during childhood affected happiness very much. This was not noticeable in the case of loss of the father. Indeed, the rating of happiness in childhood appears to be higher where parents were separated than where there has been quarrelling between parents at home.

It is interesting to notice that among children who have had religious upbringing, there is greater happiness in childhood, more sex education, and less extra-marital sex relationships. Extra-marital sex relations were found to have taken place in one-third of all married women before marriage, and one-fifth of the single women. The results suggest that pre-marital relationships are very common during the engagement period. The incidence of extra-marital relationships has a positive correlation with happiness in childhood, lack of sex education, and so forth.

It is strange to find, in a report on "The Sexual, Marital and Family Relationships of the English Woman", no reference to frequency of sex relationships or to such important aspects of sexual development as masturbation. Indeed the majority of the questions are directed towards feelings, attitudes, and expectations rather than facts. Women's memories are notoriously unreliable, particularly where their emotions are concerned, and some of the findings are difficult to believe. For example, the small proportion of women who remember feelings of aggression towards their mothers in adolescence; and the percentage of exceptionally happy and very happy marriages and those with good sexual adjustment, is higher than in any other survey of this kind. Could it be that guilt over putting their negative feelings into words prevents the not so happy from filling in their forms?

There is much of interest in this reference book for all who study the sociology of marriage and family life. Certain truths we have come to accept, notably about influences in childhood and their effect on adult personal and social relations, are underlined by its findings. Research of this kind is only a beginning in a rapidly expanding field, but the basic facts emerge more clearly with each attempt.

ELEANOR MEARS

The Historical Background of Chemistry

By Henry M. Leicester (*New York, John Wiley and Sons, Inc.; London, Chapman and Hall Ltd, 1956, 260 pp., $6.00, or 48s.*)

Dr Leicester emphasises that modern chemistry has a long ancestry stretching back far beyond the days of Lavoisier and Boyle. In the sequence of twenty-four chapters, Lavoisier enters at the fifteenth. The early chapters deal with Greek science, Chinese and Arabic alchemy, and the transmission of the incipient science into medieval Europe. Here, as throughout the book, consideration is given to successive ideas as well as to the development of practical methods. The later chapters depict the birth of the atomic theory and the consequent rapid growth of modern chemistry, opening with laws of atomic combination and passing from electrochemistry and

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chemical affinity to organic chemistry, systematic inorganic chemistry, physical chemistry, radioactivity, atomic structure, and biochemistry. All the while Dr Leicester dwells upon the progression of thoughts and ideas rather than upon the human, social, and economic aspects of his selected background, since he realises that a complete picture could not be delineated in a single volume by a single author. The account here given, with its limited objective, forms a well-knit, competent, and interesting narrative. Each chapter is well documented, and there are name and subject indexes. JOHN READ

British Medical Bulletin: Physiology of Voluntary Muscle, vol. 12, No. 3, September 1956

(*London, The British Council, 1956, 76 pp., 15s.*)

The sensations are so prominent in human life that a non-biologist might be unaware that they are only a means to an end, and that the purpose of a nervous system is to enable a living organism to do things, that is to carry out actions in response to the information conveyed in those sensations; such actions are primarily directed to the welfare of the organism or the maintenance of its species. The nervous system has only two mechanisms at its disposal for producing the desired effects, glandular secretion and muscular contraction. The importance of muscular activity therefore requires no emphasis, and it is good to see such an excellent issue of the *British Medical Bulletin* devoted to the physiology of voluntary muscle.

There is an introduction by Sir Rudolph Peters, followed by sixteen papers which review muscle proteins (K. Bailey) and their reactions during contraction (S. V. Perry), the meaning of striations (A. F. Huxley) and the ultrastructure (H. E. Huxley), thermodynamics (A. V. Hill) and energy production (D. M. Needham), muscular effort (R. G. Bannister) and fatigue (P. A. Merton), mechanical properties (D. R. Wilkie), certain aspects of neuromuscular transmission (B. Katz), the nervous gradation of muscular contraction (P. H. Hammond, P. A. Merton, and G. G. Sutton) and the changes in muscle after death (E. C. Bate-Smith and J. R. Bendall). Three papers consider the comparative physiology of muscle from very different viewpoints (A. V. Hill, J. Gray, and C. F. A. Pantin), and one article (B. McArdle) is concerned with the disease of familial periodic paralysis.

Apart from the last-named paper, the articles are written from the viewpoint of the laboratory worker. In his introduction, Peters states the truism that "practical results can follow with certainty only when the background of knowledge is complete", and he illustrates this by pointing out that "it would not be difficult to show that most of the academic research [in muscle] of the last forty years is necessary to provide a basis for a complete understanding of" familial periodic paralysis, to take as an example, the disease considered in this issue. Unfortunately, in medicine, the constant and urgent need to treat the sick makes the practitioner so bound up with his immediate difficulties that he is apt to ask for these to be solved rather than to wait for the ultimately greater benefits which follow when the research worker attacks basic problems. Clinicians unversed in the basic sciences, like army officers resistant to the introduction of new weapons, are a rapidly disappearing group, but the gap between practitioner and academic worker is regrettably not made any the less by the single-minded attachment of some academic workers to their ivory tower, and their belief that the practical implications of their work are entirely and invariably the responsibility of others. Such an attitude has without doubt contributed to the neglect of technical knowledge in this country.

The reviewer strongly recommends this issue to those with biological or medical interests. It reflects great credit upon the authors, editor, and the British Council. It provides evidence of Britain's dominant position in basic research. H. SUMMERS

"Information Theory, and its Engineering Applications"

By D. A. Bell. 2nd Edition, 1956. (*Sir Isaac Pitman and Son, 175 pp., 25s.*)

Information Theory is not really, mathematically, a difficult subject. The elements of statistics and probability theory, some Fourier analysis: these lay the main foundations. It is the concepts rather than the analysis which may seem a little bizarre, a little unacceptable to the practising engineer; information as "potential for making selections" from a source statistical ensemble, rather than the words and sentences, the clichés and jokes which form the stuff of living communication. The dehumanised abstractions, the basic assumptions, need clear explanation, in simple terms, for the beginner.

It is from such a viewpoint that this book might be criticised. Thus, on page one, line three: "Information is the negative of entropy" may grate the initiate's mental teeth before he can dig them into the substance of the subject. Next he is given controversies over relations between thermodynamic entropy and information rate, Maxwell Demons, and the subtle distinctions between the author's definition of information rate and Shannon's. No; the beginner would do well to start at Chapter 3, with Hartley's clear and simple approach to the subject, as a discussion of the relations between transient response time and signalling speed in telegraph cables; then on to the more precise formulation of expressions for information rate as a function of noise-level and of the probability of occurrence of the signals. The author has given too little thought to the order in which the rather difficult concepts may be built up and assimilated by the beginner.

This second edition includes additional material on coding and decoding, an account of several engineering applications of the theoretical matters, and a chapter on Wiener's theory of filtering. COLIN CHERRY

Parasites and Parasitism

By T. W. M. Cameron (*London, Methuen, 1956, xx+322 pp., 35s.*)

Most books on parasitology are, inevitably, of medical or veterinary interest. This is an exception. Prof. Cameron treats his subject as a branch of biology, within an evolutionary framework. For him, a parasite is any organism which has a host, that is, which lives on, or in, or off, another organism; he therefore very properly discusses symbiosis as well as parasitism in its narrower sense. His scope is indeed remarkably wide: the first part of the book deals with the whole range of parasites of animals, from fungi and viruses to those few vertebrates which qualify for inclusion; the second deals with the host and its reactions. Although the first part is arranged by phyla, systematics are kept to a minimum and the parasites are considered as living organisms in an environment to which they are specifically adapted. There is plenty of information on physiology. In the second part the general principles of epidemiology and of the control of diseases due to parasites are reviewed. There is a useful annotated bibliography. The 115 line illustrations are clear and informative. This book should have a wide circulation among students; it should also help teachers to make this important subject more attractive and better integrated with the rest of biology.

S. A. BARNETT

The Theory of Prestressed Concrete Design. Statically Determinate Structures

By Prof. H. J. Cowan (*London, Macmillan and Co. Ltd., 1956, 36s. net.*)

Rapid strides have been made in the last decade in the development of prestressed concrete as a construction medium, mainly in respect of statically determinate structures with comparatively few works incorporating continuity. In its early development the attraction of a new material together with the possible large saving in steel, sometimes prompted the use of prestressed concrete when in fact it was not the most economical solution to the engineer's problem. Today, however, designers have a better appreciation of

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NOTES AND COMMENTS

REVIEWS

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its possibilities and of suitability for particular projects, and for certain purposes it is recognised as superior to other forms of construction due to cost, speed of erection, durability, and appearance. More and more use is being made of prestressed concrete in civil engineering and building construction, and the student who is making civil engineering his career must understand how to design in this medium.

Prof. Cowan has prepared a theoretical treatment, the text being mainly taken from lectures which he gave at the University of Sheffield before taking up his appointment as Professor of Architectural Science at the University of Sydney. Published articles and papers in respect of shear and torsion have also been included, and the chapter on the ultimate strength in bending is illustrated with fully worked examples. His style and the general arrangement are well suited to the needs of students, but there are some items where the data presented are somewhat out of date, for example, in the assessment of losses of prestress, creep of steel, transmission length, and even in the descriptions of the prestressing systems. A notable omission is the absence of reference to composite constructions incorporating precast prestressed units with *in situ* concrete, which have gained considerable favour in recent years.

However, this is a sound introduction dealing essentially with direct design, as distinct from checking an existing or assumed design; and the tables on the properties of sections are useful for preparing preliminary design details. Some difficulty may be experienced in using the extensive notation, based partly on that proposed by the Institution of Structural Engineers and partly on that issued by the American Concrete Institute. Since, however, Prof. Cowan tries to appeal to readers in Britain, America, and Australia, some compromise is essential, and there is merit in his suggestions which could well form the basis of another attempt to obtain uniformity between the countries concerned. A. W. HILL

Brief Notes

The British Council has published an eight-year report of the work of the Committee for Commonwealth University Interchange, which is obtainable from 65 Davies Street, London, W.1. The Committee was set up in 1948 to facilitate the movement of university teachers and graduates within the Commonwealth. Members of university staffs ranging from vice-chancellors to young post-graduate workers have been able to visit Commonwealth countries other than their own.

The Association of Universities of the British Commonwealth have published a list of Awards tenable at universities in the United Kingdom, together with a short list of Awards tenable overseas. This is obtainable from 36 Gordon Square, London, W.C.1, and the Editor would welcome information of any omissions or errors.

"Scientific and Engineering Manpower in Great Britain" is the name of the Stationery Office report (1*s.* 6*d.* net) on the number and distribution of scientists and engineers now employed in Great Britain, and a study of the likely trend in the future demand for scientific and engineering manpower.

A new monthly journal, *Annals of Physics*, will be under the editorship of Philip M. Morse, of Massachusetts Institute of Technology and published by Academic Press, New York. Original articles on research in any branch of physics will be welcome. The first number is to appear in April 1957.

The CERN International Symposium on High Energy Physics, which last June attracted to Geneva 300 nuclear physicists from twenty countries, has now culminated with the publication of the Proceedings, in 2 volumes, 40 Sw. francs per vol., obtainable from CERN Service d'Information, Case postale 25, Geneva 15, Switzerland. Vol. 1 deals with high-energy particle accelerators, and Vol. 2 with pion physics and experimental techniques, including the dramatic announcement by Prof. W. Pauli of the first experimental verification of the long-elusive neutrino, which had been hypothesised by Prof. Pauli himself about twenty years ago. The verification took place at Los Alamos.

The new *International Journal of the Physics and Chemistry of Solids* is to be edited by Harvey Brooks of Harvard, with associates in Paris, Eindhoven, Brookhaven, and Moscow. Sample issues may be obtained from Pergamon Press, 4 Fitzroy Square, London, W.1.

The Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, publish their report for the year ended March 31, 1956. Dr. J. T. Scales has been working at the Institute of Orthopaedics of the British Postgraduate Medical Federation on the problem of plastic substitutes for bones. £20.000 has been offered over a five-year period to the University of London for the maintenance of a biomechanical unit for this work. It will apply mechanics to the study of the forces and actions of the living body, both on the musculoskeletal system and on the flow of fluids and gases in the body. An engineer, Mr W. K. Taylor, has been investigating problems of designing mechanical "brains" and has built machines based mainly on experiments made with the octopus. The latest machine, when shown a shape, "looks" at it and judges which previously learned shape the new one resembles. These are only a few of the many activities of the Foundation.

The Methuen monographs on physical and chemical subjects have long been popular with scientists needing concise, authoritative reading which they can fit into their pockets. Two new additions to the physical series are: "Order-Disorder Phenomena" by E. W. Elcock, dealing with binary alloys and non-stoichiometric alloys, and "Frequency Modulation" by Arguimbau and Stuart, which discusses particularly the reduction of extraneous disturbances during transmission. The latest title in the chemical series is "pH Measurements, Their Theory and Practice" by Victor Gold. The book starts at an elementary level, and is suitable for biologists, physicians, physicists, and engineers as well as chemists.

Pergamon Press Ltd. have published a "Handbook of Magnesium-Organic Compounds" in three volumes at a price of $72 or £24 the set. The first two volumes list 13,395 compounds in the international nomenclature as confirmed by the International Commission held at Liège in 1930. Vol. 3 cross-indexes the end-products, compounds, authors, and co-authors.

"A Short Course in Radiological Protection" is a useful duplicated booklet by the Health Physics Division and Isotope School, AERE, Harwell, England. Papers are included on the elements of nuclear physics, the energy of various radiations, the organisation of a radiation protection service, the maximum permissible levels of radiation, external radiation hazard and its control, and allied subjects. The price is 13*s.* 6*d.*

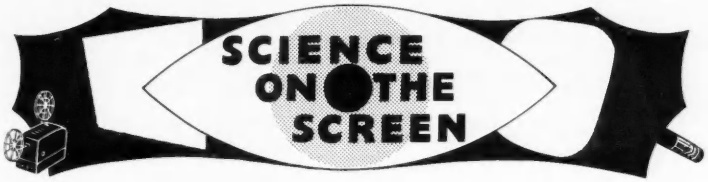
"Atomic Energy", a series of four explanatory talks by Jack Diamond, H. J. Grout, J. L. Putman, and Sir John Cockcroft, is published in leaflet form by the BBC, 35 Marylebone High Street, London, W.1. The talks are reprinted from *London Calling*.

Oliver and Boyd, Edinburgh, have published a book on "Basic German for Science Students" (12*s.* 6*d.*). The student is given a guide to German grammar and a useful vocabulary of basic German words. Passages from scientific literature are printed in German, with English translations on the facing page and with a list of important words and their meanings underneath. There is also a vocabulary at the back.

The Annual Report for 1955 of l'Institut pour l'Encouragement de la Recherche scientifique dans l'Industrie et l'Agriculture has been published from 53 rue de la Concorde, Brussels.

The Research Defence Society, 11 Chandos Street, London, W.1, has published a small booklet on "Anti-Poliomyelitis Vaccination", price 3*d.*, answering such questions as, "What are the risks of vaccination?", and "Are vaccinated children infectious?"

"Wrought Titanium" is a brochure published by Imperial Chemical Industries, P.O. Box 216, Kynoch Works, Witton, Birmingham. ICI is using television in remote control of titanium melting furnaces. Titanium is now being used extensively in the aircraft industry.



Le Monde du Silence—The Silent World

A film by J.-Y. Cousteau. 35 mm. Technicolor. 82 minutes. Distributed by J. A. Rank Film Distributors Ltd.

"Il va dans l'immensité noire, portant son cœur comme un flambeau." That is Jacques-Yves Cousteau, the man who has more than any other opened the underwater world to us and who realised the dream which Jules Verne so accurately foretold. Cousteau has indeed carried the flaming torch of exploration into the black depth of the sea, and in this, his latest film to be seen in this country, he has literally lit up the underwater scene with bright artificial lights. If one compares *The Silent World* with *Wrecks*, the first of his films of 15 years ago, one cannot but be amazed at the progress Cousteau has made in his technique of underwater cinematography and exploration. His latest cameras, built by André Laban with the famous Dratz lenses, have allowed him to use colour film, and by the use of underwater electric lamps he has been able to portray colours on the screen which neither fish nor men had ever seen before. The introduction of self-propelled and electrically driven underwater scooters to which the diver holds on with his hands and which can pull up to three divers each, has in one stroke freed the frogman from his own muscular effort and allowed him to roam widely and speedily in his element. Alone the faithful *Calypso*, the expedition's base-ship, has remained the same throughout the years.

The subjects of the film, like those of the book with the same title, are many, often novel, and sometimes of breath-taking beauty. Nitrogen narcosis is discussed, porpoises are filmed from a special observation chamber in the bows of the *Calypso*, the deep-scatter layer is investigated with Edgerton's underwater flash-camera, and cinematographic records are taken at the greatest depth yet reached by a cameraman, 247 feet. Plant and marine life in the Mediterranean, the Red Sea, Indian Ocean, and Persian Gulf form the background against which wrecks are searched and surveyed, fish are befriended, studied, and filmed, and where always the detached and scientific spirit of exploration is uppermost in Cousteau's team: a fact which distinguishes his film and his work from that of others. Drama is not absent from *The Silent World*: a young sperm whale is lacerated by the screws of the *Calypso* and the gruesome attack by a rabble of sharks is filmed in close-up. Perhaps most beautiful are the gay colours of the coral fish, looking often like modernistic art designs, and amongst the many scenes never filmed before, the underwater views of swimming sperm whales recorded from directly behind, are fascinating in their grandeur and power. A brief land sequence shows the laying of eggs by giant turtles, which Noel Monkman filmed in greater scientific detail some years ago on the Barrier Reef.

There are few faults to be found in *The Silent World*. The drums and trumpets of the Republican Guard are not appropriate background music for porpoises. Excellent as sound effects were the noises of breathing underwater, the hiss of inhaling and the cheerful bubbling of breathing out. Cousteau himself speaks the commentary in a pleasant, clipped naval tone. Louis Malle as co-director and cameraman, Fréderic Dumas as the leading diver, Edmond Sechan as director of photography, and Georges Alépée as the editor of the film all deserve congratulations. Cousteau himself will be content to know that through this film hundreds and thousands of people all over the world will be able to share with him the pleasures of exploring a silent underwater world.

A. R. MICHAELIS

Treasure Seekers in Our Mountains

Produced in 1955 by the Central Newsreel and Documentary Film Studio, Peking, China. Distributed by the Britain-China Friendship Association (35 mm) and Plato Films (16 mm). Colour. 40 minutes.

It is strange that the fascinating world of geology, with its wealth of minerals and fossils, all bound up with the history of the Earth, and involving real adventure in exploring unknown regions, has not been exploited by scientific film-makers. Some would say that geological films are scarce because only three things move in geology—lava, water, and geologists themselves. There are indeed one or two films on erupting volcanoes (with lava dominating the cast list), and a few on moving water (usually on river and sea erosion). There are now even elementary films on the origin of certain fuels ("How Oil Occurs", "How Coal is Formed"), and specialised ones on the use of instruments such as the polarising microscope. But there are no English-language films showing geologists at work, and none set out to show how attractive geology can be as a career.

"Treasure Seekers" is a recent Chinese film designed to attract young people into this adventurous and essentially outdoor science. It is sponsored by the Chinese Ministry of Geology and shows the training of young geologists of both sexes and their subsequent work in locating new mineral deposits.

After a brief review of some of China's mineral resources (peridotite, iron-ore, copper, and petroleum), prospecting activities in various provinces of China are shown, including seismic geophysical work in the Gobi Desert. Some of the scenic shots, such as those along the Yangtse River, are geologically interesting but unfortunately short. We are then shown students at work in the Geological Institute at Peking, where they apparently even undergo "fitness training", and run about with laden rucksacks!

The main part of the film, however, shows two student expeditions, one prospecting for iron-ore at Chienlin in Central China, and the other exploring in the Chinghai province on the Tibetan borders. The stories of the two parties are interwoven.

At Chienlin we see various prospecting methods being used: geophysical, palaeontological, mineral sampling and identification, and actual drilling. Towards the end of the film, and with the iron-ore still undiscovered, a slightly dramatised sequence shows the party plotting information and calculating results throughout the night, eventually, of course, to be rewarded with success.

The other party is shown travelling across rugged terrain by means of waggons, horseback, and eventually yaks to Tibet. There are some grand views of mountain scenery, with climbing sequences while surveys are made. Eventually peridotite (containing chromium, nickel, and platinum) is found, and the party celebrates at the base camp.

The film, which has English sub-titles, is well photographed and the colour is excellent throughout. School audiences and geology students should see it; they will be amused by Oriental ways, but they cannot fail to be fascinated. Every geologist will immediately begin to visualise what a similar film on the training of British geologists would be like, and what locations could be used.

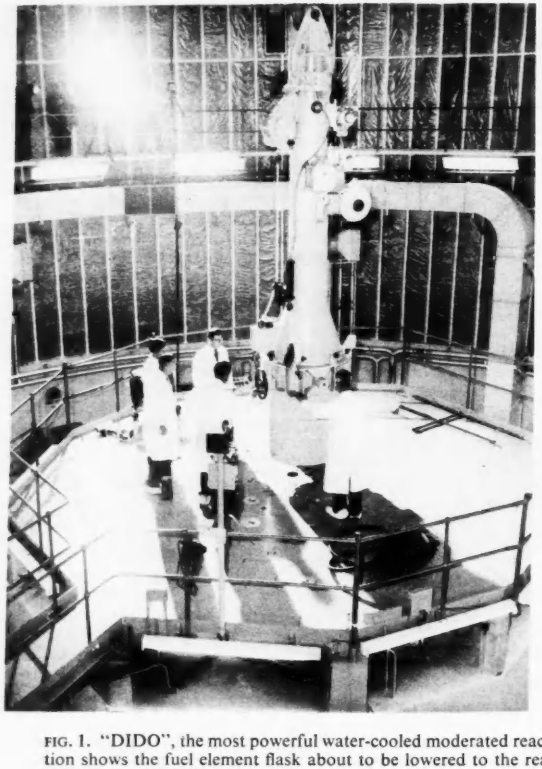
G. THOMAS

Great Day

Directed by Frank Green for the U.K. Atomic Energy Authority, and distributed by Ace Distributors. Colour. 35 mm. 20 minutes.

This film of the opening of Calder Hall by the Queen is for general distribution at home and abroad, and has achieved a nice balance of attractiveness and information. The diagrams showing how a thermal reactor works are clear and explicit, and the Queen speaks graciously, and with a historic sense of the occasion of which Britain can be proud.

I. NICHOLSON



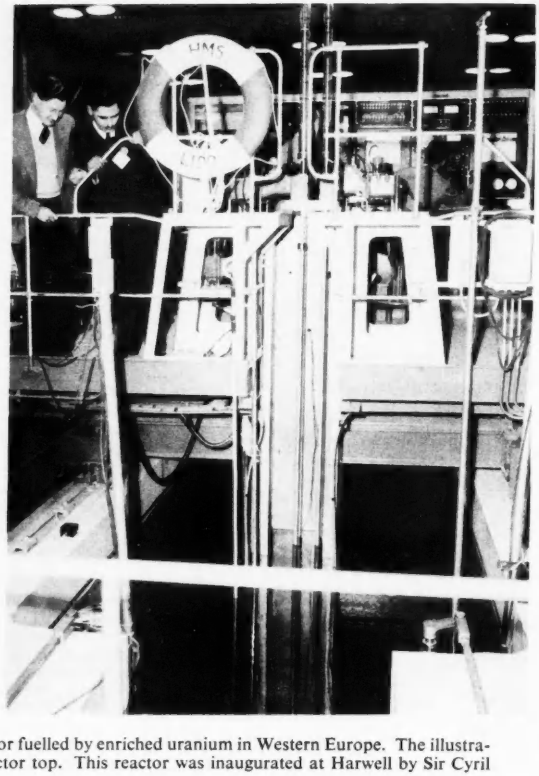


FIG. 1. "DIDO", the most powerful water-cooled moderated reactor fuelled by enriched uranium in Western Europe. The illustration shows the fuel element flask about to be lowered to the reactor top. This reactor was inaugurated at Harwell by Sir Cyril Hinshelwood, P.R.S.

FIG. 2. "LIDO" reactor which has been built to carry out shielding experiments and assist in the development of a British Submarine Propulsion Unit. A movable trolley is mounted on top of the purified-water tank, and the reactor core of enriched uranium is lowered into the tank.

FAR AND NEAR

Lido, the Swimming Pool Reactor

"LIDO", the latest research reactor at Harwell, started operating for the first time during the night of September 20–1. This reactor is intended primarily for shielding studies: one of its major tasks is to assist in the development of the British Submarine Propulsion Unit. It is a "swimming pool" type reactor in which the enriched-uranium plate-type fuel elements are suspended in a large concrete tank of purified water. The concrete tank is 24 feet deep by 8 feet by 28 feet and is surmounted by a movable trolley. Suspended from the trolley is a framework supporting the reactor core, which is about the size of a tea-chest. Shielding experiments are made by moving the core of the reactor close to aluminium windows which are set into the walls of the tank. The heat output is about 100 kW.

The detailed design and construction of the reactor was carried out by a joint Naval and Atomic Energy Research Establishment team in association with: Vickers-Armstrongs (Barrow) Ltd (Reactor Components), Ericssons Telephones Ltd (Instrumentation), Rolls-Royce Ltd (Control Gear), Marston Excelsior (Fuel Elements).

The buildings, including the reactor tank, were constructed by the Ministry of Works.

Nuclear Physics in Portugal

Portugal's Junta de Energía Nuclear, the country's atomic energy commission, has announced purchase of a 2-million-volt Van de Graaff particle accelerator from High Voltage Engineering Corp., Cambridge, Mass., U.S.A., to be used in research and training of nuclear physicists. The machine will be installed and operated in a Lisbon suburb, and will be used for investigations of protons, deuterons, and heavier ions. The versatile accelerator will be equipped with a beryllium target for use with positive-charged particles to produce neutrons. It will also be supplied with a gold target for production of super-voltage X-rays for radiography of metal fabrications. Plans are under way to set up co-operative programmes with industrial, research, and educational organisations for work in sterilisation, cross linking, food preservation, and metallurgy.

Blood Groups and Disease

The *British Medical Journal* for September 29, 1956, reports studies from a number of centres which suggest that pernicious anaemia is commoner in persons of Group A blood than in those of Groups O and B. In the same issue workers at the Heredity Clinic, United Liverpool Hospitals, and the Genetics Laboratory, University of Oxford, suggest that previous evidence of an association between Group O blood and duodenal ulcer may in fact have been misleading, since no such evidence was found in their own extensive study.

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V-2	2.0	3.0	—	—
V-5; V5-H	5.0	7.5	2.0	2.6
V-6; V6H	6.0	7.5	3.0	3.75
V-10; V-10-H	10.0	13.0	4.0	5.2
100Q; 100-R	15.0	17.5	8.0	9.0
V-20; V20H	20.0	26.0	8.0	10.4
V-30-H	—	—	15.0	17.5
50A; 50-B	40.0	45.0	20.0	31.0
M-2	2.0	3.0	*For use on 350-1200 c/s.*	
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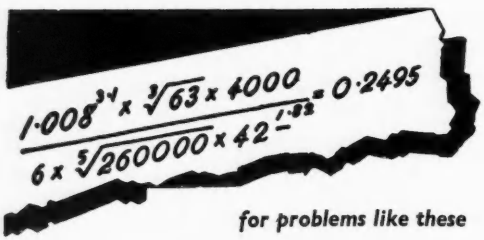

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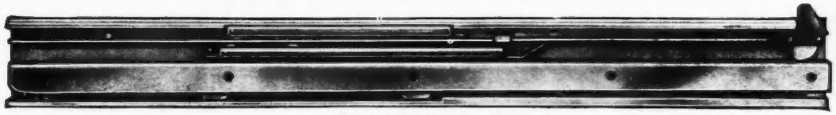

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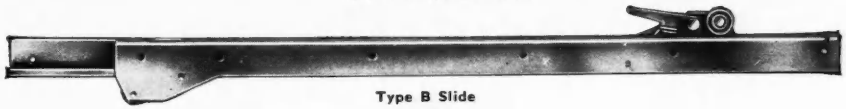

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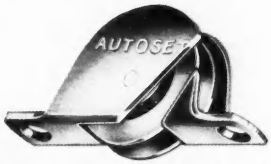

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